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MEMOIRS
OF THE
MUSEUM OF COMPARATIVE ZOÖLOGY,
AT
HARVARD COLLEGE.

VOL. II.

UNIVERSITY PRESS, CAMBRIDGE,
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ILLUSTRATED CATALOGUE
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MUSEUM OF COMPARATIVE ZOÖLOGY,
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NO. III.
MONOGRAPH OF THE NORTH AMERICAN ASTACIDÆ.

BY
DR. HERMANN A. HAGEN.

CAMBRIDGE:
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N O T E .

It is but justice to DR. HAGEN to state that this monograph was completed by him and handed to me for publication as early as October, 1868. Circumstances over which I had no control have delayed its passage through the press till now.

LOUIS AGASSIZ.

CAMBRIDGE, February 21, 1870.

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Plate VI.

Cambarus pellucidus, Male Form I. (nat. size).

Plate VII.

Cambarus advena, Male Form I. (twice enlarged).

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Plate IX.

Cambarus obesus, Male Form I. (nat. size).

Plate X.

Astacus Trowbridgii, Fem. Type (nat. size).

Plate XI.

Astacus Gambelii, Male. Type (nat. size).

INTRODUCTION.

THE following monograph of the Fresh-water Crawfishes of North America is intended to form the first step in a scientific examination of the rich crustacean materials contained in the Museum of Comparative Zoölogy at Harvard College, in Cambridge. The excellent monograph of the genus *Callinectes*, published by Mr. A. Ordway in 1863, is the only work about Crustacea, based principally upon the Cambridge collection.

Arriving in Cambridge in October, 1867, in order to take care of the articulated animals belonging to the Museum, I was charged first to arrange and put in order the Crustacea. Because of the almost total lack of room and of working hands (the rich collections from Brazil procured by the Thayer Expedition having occupied all working time for the last two years), but a small part had been as yet determined and arranged in the rooms opened for public exhibition. The greater portion of them had been stored for several years in the cellar, and therefore was so situated as not to be readily accessible for a scientific examination.

The part exhibited comprised a series of three hundred and twenty-seven determined species in a systematical collection, also three hundred and thirty-seven determined species in several faunal collections, and a few types of the United States Exploring Expedition. Nearly all the latter species being represented also in the systematical series, the number of named species (determined mostly by Mr. Dana and Mr. W. Stimpson) did not perhaps exceed five hundred. With the exception of several boxes already separated, with duplicates for exchange, they answered to a catalogue of nearly sixteen hundred numbers, containing the names of the respective localities and collectors, the dates of capture, and, in some cases, the scientific determinations by Mr. W. Stimpson.

The whole collection is now in a safe condition, mostly unpacked and arranged in new alcohol. The division of the entire assemblage has been carried as far as the families, that of the greater part as far as the genera, while several families have been critically identified. There are over four thousand two hundred jars. The number of specimens, perhaps, exceeds sixty thousand; the additions during the years 1863–1866 were fourteen thousand specimens. According to Professor L. Agassiz's estimate, the collection comprises more than two thousand species, the entire number of species as yet known being about five thousand. A closer examination of several families verifies this estimate, or rather indicates that it is probably too small. Nearly one half of the collection is formed by the Brachyura, one fourth by the Macroura.

The value of the collection is the greater from the circumstance that most of it has been secured and formed, in view of a definite plan adopted by Professor L. Agassiz for the purpose of examining and defining the different faunæ in the gigantic water-area spreading between the coast of Eastern Africa and Western America. Several persons have been charged with the collecting of the fishes, the crustacea, and the polyps at chosen points, — at Zanzibar, Mr. C. Cooke; at Kingsmill, Sandwich and Society Islands, Mr. Garrett; on the West Coast of America, Messrs. A. Agassiz, and T. G. Cary. At the same time rich collections have been received from additional intermediate localities, — Rangoon, Singapore, China, New Holland, and others, chiefly through Captain W. A. Putnam. The Museum is also very rich in specimens from the shores of the United States, from the Antilles, and from Brazil; it likewise possesses valuable materials from the European and Mediterranean fauna.

The materials examined by me for this monograph of the North American Astacidæ are, I think, as yet unrivalled. They consist of the following assemblages: 1. The Astacidæ of the Cambridge Museum, twenty-five species, represented by nearly two thousand alcoholic specimens from one hundred and fifty different collectors and as many different localities, besides some dry specimens, partly types of Dr. Gibbs. 2. The Astacidæ of the Museum of the Philadelphia Academy, kindly communicated to me by Professor Leidy, containing types of Messrs. John LeConte and Girard. 3. The Astacidæ of the Museum of the Natural History Society in Boston, containing types of Professor W. Stimpson. 4. The Astacidæ of the Museum of the Peabody Academy in Salem, which, with the last, were kindly communicated to me by Dr.

A. S. Packard. 5. Types of nine species of Mr. Girard and Professor W. Stimpson, kindly communicated to me by Professor W. Stimpson.

The Astacidæ in the collection of the Smithsonian Institution I have not yet seen.

I have described thirty-eight species, — thirty-two Cambari and six Astaci. Eleven species, all Cambari, are new. There are six species — four Cambari and two Astaci — which I have not seen.

Among the twenty-eight species of *Cambarus* which I have examined I have seen the two forms of the male, and the female of twenty-three species, the first form of the male and the female of one species. There are two species, of which I have seen only the first form of the male ; of one species I have seen only the second form ; of five species I have seen but single specimens ; of all others, a considerable number.

Among the four species of *Astacus* which I have examined I have seen of one species both the male and female ; of another species, the male only ; of the other two species, the female only ; and in all cases only a few specimens of each species.

This monograph, as I am convinced, is very far from embracing the entire number of species living in North America. May new explorations soon render my work incomplete.

HISTORY OF THE AMERICAN ASTACIDÆ.

1798. THE first North American species made known was described by Fabricius, in his *Supplementum Entomologiæ Systematicæ*. It was called *Astacus Bartonii*, and communicated by Professor Smith Barton. The description is very short, and the locality not given, but it is probably the species more recently determined as *A. Bartonii* by American naturalists. Bosc, Hist. Nat. des Crust., Suites à Buffon an x. (1802), describes in few words, repeated by Latreille, Hist. Nat. des Crust., VI. 240, *Astacus Bartonii*, which he collected in America. The figure given by him is very bad, and it is impossible to identify his species.

1817. Rafinesque, in the American Monthly Magazine, II. 42, November, describes four species, — *Astacus limosus*, *fossor*, *ciliaris*, and *pusillus*. His descriptions are likewise very short, but the locality is given, and it will therefore be possible to determine them exactly by further investigations.

A. limosus is perhaps *A. affinis* Say, and *A. fossor* the species described by me as *A. obscurus*, if it has burrowing habits. *A. ciliaris* is apparently *A. Bartonii*, but the dimensions given by Rafinesque are, as for the foregoing species, excessive. The ciliated legs do not belong exclusively to this species. I think *A. pusillus* does not differ from *A. ciliaris*. The differences given are not important, — “the rostrum oval acute,” “the hands oblong, dotted,” “entirely fulvous brown”; in *A. ciliaris*, “the rostrum short, acute,” “the hands short, thick dotted,” “entirely olivaceous brown.” Perhaps *A. pusillus* is the second form of the male; still, ciliæ always occur on its second pair of legs, and Rafinesque would have mentioned the fact in this instance no less than in *A. ciliaris*.

One month after the appearance of the account of Rafinesque, Th. Say, in Journ. Acad. Phil., I. Part I. 167, December, described two species, — *A. Bartonii* and *affinis*. His descriptions are good, and sufficient to designate the species. A supplement is given, l. c. 443, concerning the variation of their armature and the proportion of the hands in *A. Bartonii*; but here perhaps Mr. Say speaks of a different species. *Astacus Bartonii* Say is probably the species described by Fabricius, and *Astacus affinis* seems to be *Astacus limosus* Rafinesque.

The better description authorizes us to prefer a name published one month later.

1830. R. Harlan, in Trans. Amer. Philos. Soc. Phila. III. 464, gives the description of *Astacus Blandingii* from South Carolina, repeated in 1835 in his Medic. and Phys. Research. 229, with the addition of short specific characters of *Astacus Bartonii* and *affinis*, and the figures of the three species. But the numbers of two species are erroneously changed in the drawings. The specimen types preserved in the collection of the Philadelphia Academy have been kindly communicated to me by Professor Leidy.

1833. John D. Godman, in Rambles of a Naturalist, Philadelphia, pp. 40, 41, has communicated his observations upon the burrowing habits of *Cambarus Diogenes*. I have not seen this work, which is quoted by Mr. Ch. Girard.

1837. Professor Milne-Edwards, of Paris, in his Hist. Nat. des Crust., II. 331, describes *Astacus Bartonii*, *affinis*, and *Chilensis*. The change of the numbers in Harlan's figures has apparently induced him to reverse the names of the two species.

1839. Mr. J. W. Randall, Journ. Acad. Phila., VIII., Part. I. 138, describes *Astacus Oreganus* from the Columbia River, figured in pl. 7. The description is very short and the figure apparently very erroneous. The type was lost by the artist, and it is still impossible to identify the species.

1842. De Haan, in Faun. Japonic. Crust., 164, has observed the interesting fact that *Astacus Bartonii* and *A. affinis* possess one gill less than *A. fluviatilis* and *Japonicus*. The gill on the fifth pair of legs is wanting.

Professor Z. Thompson, in his Natural History of Vermont, 170, notes the occurrence of *Astacus Bartonii* in that State.

1844. In J. Mueller, Archiv. 383, Dr. Tellkampff describes the remarkable blind species from the Mammoth Cave in Kentucky, *A. pellucidus*.

James E. De Kay, in his Zoölogy of New York, Part VI., Crustacea, 22, gives the description and figure (pl. 8, fig. 25) of *Astacus Bartonii*, and the diagnoses of *A. affinis*, *Blandingii*, and *Oreganus*.

1845. I. E. Gray published in Journals of Exped. of Discovery in Central Australia, by E. J. Eyre, a paper on some *Astaci* from New Holland, in which he suggests that the genus *Astacus* may be divided into three sections, characterized by the texture of the caudal segment, in being calcareous or not to its top. Mr. James D. Dana has proved that this character cannot be of much value in classification.

1846. Erichson, in Wiegmann's Archiv. Jahrg., XII. 86, and supplement, 375, gives an elaborate monograph of the whole genus *Astacus*. He describes from America, *Astacus pellucidus*, *affinis*, *Carolinus*, *Bar-*

tonii, *Blandingii* (after Harlan's description and figure), *Wiegmanni*, *Mexicanus*, *Cubensis*, *Chilensis* (after M. Edwards's description), and *Oreganus* (after Randall's description and figure). His materials were few; of *A. pellucidus* and *affinis* he saw but one specimen, but his descriptions are largely comparative. The observation first made by De Haan, that the American species possess no gills at the base of the fifth pair of legs, is repeated and verified in the other species described by Erichson, and taken for the formation of a particular subgenus, *Cambarus*. Erichson's monograph is still unrivalled, comprising all the species of the whole world. Still, there is no certainty in the determination of the species which he described, since so many similar species have been more recently found. But it is possible to arrange them in my groups, as Erichson has noted the number of hooked legs of the males. His types are preserved in the Berlin Museum, and an examination of them will prove, perhaps, that in the case of some species my determinations are erroneous.

1850. Mr. Lewis R. Gibbes, in his work "On the Carcinol. Collect. in the U.S.," 31, quoted *Astacus Bartonii*, *affinis*, *Blandingii*, and *pellucidus*. But the localities given by him are doubtful, as I have seen very different species presented by him, under the same name, to the Philadelphia and the Cambridge Museums.

1854. The richness of the materials preserved at the Smithsonian Institution in Washington, and chiefly collected by Professor S. F. Baird, led Mr. Ch. Girard to examine them critically in "A Revision of the North American *Astaci*, with Observations on their Habits and Geographical Distribution," Proc. Acad. Phil., VI. 87, and to characterize them briefly, deferring to another opportunity more full descriptions, accompanied by the necessary illustrations. Mr. Girard enumerates twenty species, eleven of which are new. Two, *C. Oreganus* and *fossor*, he had not seen. Professor Stimpson has kindly communicated to me the types of five of the eleven new species, namely, *C. Clarkii*, *propinquus*, *montanus*, *rusticus*, *longulus*, and the types of two species described before, namely, *A. Bartonii* and *affinis*. The Museum of the Philadelphia Academy possesses also some species labelled with Mr. Girard's names, which were kindly communicated to me by Professor Leidy. I do not know whether these specimens are types, since some are marked with a ?; but as they are mostly from the localities quoted by M. Girard, their identity is probable. These species are: *C. Pealei* ? from the Potomac, *C. rusticus* ?, *C. montanus* ?, *C. Diogenes* ? from the District of Columbia, *C. acutissimus* from Kemper County, Missouri, *C. Blandingii* from South Carolina, *C. robustus* from the Humber River at Toronto, *C. propinquus* ? from Garrison Creek, Sackett's Harbor, *C. montanus* ? from the James River, Virginia. Also, of the twenty species enumerated by Mr. Ch. Girard I have certainly not seen his types of

the five following: *C. pellucidus*, *Carolinus*, *pusillus*, *Nebrascensis*, *acutus*, nor the two species which he had not seen himself, *C. Oreganus* and *fossor*.

Mr. Ch. Girard has adopted the generic name *Cambarus* Erichson for the American species described by him. The introduction to Mr. Ch. Girard's Revision, etc., "according to recent investigations (Erichson is here quoted alone), the crawfishes, or *Astaci*, have been distributed into several genera," does not agree at all with Erichson's words. Erichson, in his monograph, p. 86, in dividing the old genus *Astacus*, expressly says: "The five groups quoted seem to have a higher value than merely subdivisions. Perhaps hereafter they will constitute genera. They may provisionally be regarded as subgenera." Mr. Girard added that Mr. James D. Dana had reclaimed the genus *Astacus* for North America by a species from the Columbia River, — *A. leniusculus*. Subsequently, Proc. Acad. Phil., VI. 375, Professor Agassiz stated that *C. Gambelii*, described as *Cambarus* by Mr. Ch. Girard, possesses six pairs of gills like the crawfishes of Europe, and does not belong to *Cambarus* at all. This statement is the more striking, as Erichson only gives as the character of *Cambarus*, "no gills on the fifth legs." The reply of Mr. Ch. Girard, l. c., p. 381, that he was not satisfied that this peculiarity is of generic value, and consequently that he described *C. Gambelii* as *Cambarus* with the same propriety as he might have placed it in the genus *Astacus*, gives no more light upon the characters of generic value which induced Mr. Ch. Girard to separate *Cambarus* as a distinct genus. In his Revision, etc., nothing more is said concerning this point, and he has not given any other character for his genus *Cambarus*, including *C. Gambelii* and *Oreganus*.

It is to be regretted that Mr. Ch. Girard has not fulfilled his plan of giving more full descriptions, accompanied with the necessary graphic illustrations. His short descriptions are not sufficient to indicate his new species with certainty, and for the species previously published the synonymy alone is given, for which reasons it is impossible to prove that his determinations are unquestionable. It is to be acknowledged as a fact of value, that Mr. Ch. Girard first used in his descriptions the specifically different shape of the first pair of abdominal legs in the male, and the different breadth of the dorsal area.

He has divided the species into three groups, with the following characteristics: I. Rostrum subquadrangularly elongated, terminated anteriorly by three conical and acute spines, the two lateral smaller than the middle one, which forms the tip. Extremity of the anterior pair of abdominal legs in the male straight and acute. (7 spec.) II. Rostrum generally broad, conical, and short, with margins entire and toothless, terminated anteriorly by an acute and comparatively short point. Anterior pair of abdominal legs in the male recurved at their extremity,

the tip of which is rounded. (9 spec.) III. Rostrum very much elongated, conical, tapering, provided on both sides and rather near the extremity with a small and acute spine, sometimes, however, but very slightly developed. (4 spec.)

Concerning the species described by Mr. Ch. Girard, — I have given my opinion at some length in my descriptions, — I may here make the following remarks: *C. Pealei* I consider as a full-grown *C. affinis*; *C. montanus*, *Diogenes*, and *pusillus* I am not able to separate from *C. Bartonii*; and *C. longulus* is possibly an abnormal specimen of the same species. *C. Blandingii* is not the species described by Harlan, but is *C. troglodytes*, Le Conte. *C. acutissimus* is the second form of the male of *C. acutus*. Some of my determinations may be incorrect; I hope hereafter to be able to compare the typical specimens preserved in the collection of the Smithsonian Institution.

The description and the detailed account of the burrowing habits of *C. Diogenes* given by Mr. Ch. Girard are very interesting, and, so far as I know, they are still the most complete description of this peculiar manner of living. Besides the remarks by Mr. John D. Godman, which I have not seen, Professor Erichson has mentioned the burrowing habits of some Australian species, and in the last edition of Cuvier's "Regnè Animal," the burrowing habits of an American species which severely damages the rice-fields of the Southern States are quoted from a communication by Dr. John Le Conte.

1855. Dr. John Le Conte has given, in the Proc. Acad. Phila., VII. 400, "Descriptions of new Species of *Astacus* from Georgia." Of the species described by Mr. Ch. Girard all but one are from the South, the others are from the Northern, and mostly from the Eastern States. Therefore Dr. John Le Conte's monograph is far more interesting. He describes nine species from Georgia, eight new; and there are two more, only seen by him. He remarks that he has preferred the old generic name *Astacus*, because the very slight and not very apparent differences which has been adopted to distinguish these two genera appear to him of little moment. Their color, says Dr. John Le Conte, is generally lost with their life, so that it is of little value in the description. "All that I have ever seen were much of the same color, — a reddish brown, inclining to dark olive." I do not find that any marks can be definitely pointed out by which we can distinguish those which are subterranean from those which are aquatic. It is possible to determine the species by the elaborate descriptions, especially by the shape of the rostrum and the hands, and the breadth of the areola. The types of six species, contained in the Museum of the Philadelphia Academy, have been kindly communicated to me by Professor Leidy, viz. *A. troglodytes*, *spiculifer*, *fossarum*, *angustatus*, *latimanus*, *advena*.

Concerning his species, I would remark that *A. troglodytes* is sy-

nonymous with *C. Blandingii* Girard, and that from this species I am not able to separate *A. fossarum*. But having seen only one female type, the identity must be proved by further investigation. *A. Blandingii* Le Conte is identical with *C. Lecontei* Hagen, or perhaps with Harlan's species. *A. spiculifer* is without doubt a new and good species, but I am not able to separate it decisively from the type *A. angustatus*. *A. latimanus* and *advena* are new species; *A. maniculatus* is entirely unknown to me.

After these reductions, we find the number of different species in the United States to be twenty, — fifteen given by Mr. Ch. Girard and five by Dr. John Le Conte.

1852. Professor James D. Dana, in his *Synopsis Familiarum Crustaceorum*, in the *Proc. Acad. Phila.*, VI. 15, divided the old genus *Astacus* into two genera, *Astacoides* (segmentum abdominis maris primum appendicibus carens) and *Astacus* (segmentum abdominis maris primum appendicibus instructum). With *Astacoides* are united *Engæus* and *Cheraps*, with *Astacus* *Cambarus*. He describes (p. 20) *Astacus leniusculus* from the Columbia River "pedesquinti branchias parvas gerentes." In his celebrated work, *United States Expl. Exped.*, *Crustacea*, I. 522, he says: "Among the distinctions subdividing the genus *Astacus*, that of the presence or absence of prehensile appendages to the first abdominal segments in males, fitted for use in coition, appears to be of the first importance. But the texture of the caudal segment, whether calcareous or not to its tip, cannot be of much value in classification, for it varies in the same species with age, and must therefore be somewhat dependent on the size of the species. The presence of a branchia to the posterior pair of legs may prove to be a characteristic of importance, requiring a subdivision accordingly; but of this we doubt. In the American species without this branchia, which the author has examined, the medial posterodorsal region of the carapax is narrow linear, while in the European species and that from Oregon, having the full number of branchiæ, this region is quite broad. But we cannot say how far this is generally true. For the reasons stated, we accept of *Astacoides* as a distinct genus, separated from *Astacus* by the absence of appendages from the first segment of the abdomen, and we unite with it *Cheraps* and *Engæus* of Erichson. The occurrence of the *Engæi* in holes in moist earth is not peculiar to that group, for the same habit has been observed by Professor S. F. Baird in an American species. *Cheraps* may perhaps be retained as a subgenus under *Astacoides*, on account of the absence of the posterior branchiæ; and, on the same ground, and no other of importance, *Cambarus* may be retained as a subgenus under *Astacus*." For this reason the author has retained *Cambarus* as a subgenus under *Astacus*, in his *Synopsis*, I. 523, and in the revision and emendation, II. 1433.

Astacus leniusculus is described, p. 524, and figured, pl. 33, fig. 1. I have never seen this species. *Astacus Bartonii*, locality uncertain, possibly from Brazil, is described, p. 525, and figured, pl. 33, fig. 2. The figure differs from all *C. Bartonii* which I have seen, even from the types communicated by Professor Stimpson and Professor Leidy. The rostrum, the antennal lamina, the areola, and the hand are so different in shape that evidently there must be a mistake. The patria, "possibly from Brazil," is another stumbling-block. In the Museum of the Philadelphia Academy are two *Astaci* labelled *Potamobius* spec. West Indies, and one labelled Bahia. But all three are undoubtedly the European *Astacus fluviatilis*. Perhaps the labels have been changed. Another small specimen, labelled Brazil, agrees in the shape of the rostrum with the figure given by Dana, but this curious species is neither an *Astacus* nor a *Cambarus*, but perhaps a *Cheraps*. It is a male, without the first pair of abdominal legs. Astacidæ must be very rare in Brazil, as it was impossible for Professor Agassiz and the members of the Thayer Expedition to obtain any specimen, or even to ascertain the existence of any *Astacus* species, in the vast country investigated by them. It must be remarked that Erichson has never seen the *Astacus Chilensis* mentioned by him; perhaps it is not a *Cambarus* at all.

1857. Professor W. Stimpson, in "The Crustacea and Echinodermata of the Pacific Shores of North America," Journ. Boston Soc. N. H., VI. (and separate, Cambridge, 1857-58, p. 93, pl. 6), gives detailed descriptions of three new species, — *A. nigrescens*, from San Francisco; *A. Trowbridgii*, from Astoria, and *A. Klamathensis*, from the Klamath Lake. Also shorter notices of *A. Gambelii*, *A. leniusculus*, and *A. Oregonus*. He has kindly communicated to me the types of the new species. They are apparently a very valuable addition to the North American fauna, as is also the negative fact that as yet not a single species of *Cambarus* has been found in the States of the Pacific shores.

1866. Spence C. Bate, in "Vancouver Island Crabs," in the Naturalist in Vancouver's Island and British Columbia, by J. Keast Lord, London, II. 278, says that *A. Klamathensis* is to be found in all streams east of the Cascades.

1864. Mr. H. Lucas has given a Note on *Astacus pellucidus*, which I have not seen, in the Bullet. Soc. Entom. Paris, p. iv.

1857. Mr. H. de Saussure, in Geneva, describes in his "Note carcinologique zur la famille des Thalassides et sur celle des Astacides," Rev. et Magas. de Zoologie, IX. pp. 99-102 et 503, three new species of *Cambarus* from America, *C. consobrinus* from Cuba, *C. Montezumæ* and *C. Aztecus*, both from Mexico. The descriptions are too short for a certain judgment, especially as I have not seen any species from Cuba, and but one female from Mexico. It is impossible, from the descriptions alone, to separate *C. consobrinus* from *C. Cubensis*, and the two other species from *C. Mexicanus*.

1858. Mr. H. de Saussure, in Mém. de la Soc. Phys. de Genève, T. 14, Pars II., pp. 456–461, Tab. III. f. 21–23, gives detailed descriptions and figures of the three before-mentioned species. His remark, that the *Cambarus* prefer the marshes and muddy waters, is apparently not of general value. Many species of *Cambarus*, perhaps the greater part, live in pure running water; for some species it is directly stated by Dr. LeConte.

I find it impossible to separate the species described by Mr. De Saussure from the species described by Mr. Erichson, but a judgment from two descriptions (I have seen only one female) is always doubtful. I am not sure that the hooked legs described by Mr. De Saussure correspond with those of Mr. Erichson. I think Mr. De Saussure's second and third pairs of legs are the third and the fourth of Erichson, the latter commencing the numbering of the legs with the great claws, Mr. De Saussure beginning with the pair next after the great claws. I think the words in the Note by *C. Montezumæ*, "son *C. Mexicanus* en est bien distinct par le troisième article inerme de la quatrième paire des pattes," is otherwise not intelligible. In *C. consobrinus* the second joint of the legs is said to be hooked; if this be not a typographic error, it is a strange exception.

C. consobrinus is not at all compared with *C. Cubensis* Erichs.; perhaps it is unknown to Mr. De Saussure. The two descriptions show no difference. The lamina of the antennæ, f. 21, b., has no apical external spine, — perhaps an error.

C. Montezumæ does not differ from *C. Mexicanus*, and *C. Aztecus* seems identical with *C. Wiegmanni*. But I confess that my materials are too imperfect to decide this question.

ON THE CONSTANCY OF THE SPECIFIC CHARACTERS AMONG ASTACIDÆ.

The examination of the constancy of the specific characters was a chief point in my labor, especially because Mr. Gerstfeldt, in his excellent monograph concerning the fresh-water Crustacea of Europe, has reduced the number of described species to only two, by proving that the characters relied on in their separation are far from being constant.

The exceedingly rich mass of material before me, thus far unrivalled for such a labor, has permitted a very extensive and careful examination of the constancy of the characters. Otherwise viewed, it could not be denied that this rich material — there being more than a hundred specimens of some species — would rather serve to obstruct the judgment of the worker.

Dr. J. Le Conte, in his careful monograph of the Astaci of Georgia, says: "The shape of the rostrum and of the chelæ and the size of the

areola vertebralis affords the best characteristic marks. I have never known this last character to vary in any degree. In the two others there may occur slight differences of development, not, however, so great as to be of any moment." According to these remarks, Dr. J. Le Conte seems to be convinced that the size of the areola vertebralis is alone constant and always identical, and thus confirms the result of the labor undertaken some years afterward for the European species by Mr. Gerstfeldt. I have to add that Mr. Gerstfeldt does not speak at all of the areola vertebralis, because it is not so well marked in the true *Astacus*, and that Mr. Gerstfeldt also has proved all the other characters to be variable in some degree. I am obliged to go a little further, and to state that, according to my observations, even the areola vertebralis varies to a greater or less extent.

Abnormal Gigantic Specimens. — It is very necessary to give up the idea that specific characters should bear a mathematical identity. Crustacea, as is well known, grow continually, and possibly become very old. Therefore we sometimes find of a species, which commonly has certain and smaller dimensions, some old and gigantic individuals, differing in many characters (viz. in sculpture, armature, relative size of parts and members) from the common examples of the same species. As progress is made in the cultivation of the land, and the improvement of the rivers, and especially as the population of the country increases, these giants become more and more rare in the species used as food, as in *A. fluviatilis* of Europe. Perhaps the extraordinary dimensions given by Rafinesque fifty years ago—for *A. limosus* nine inches, for *A. fossor* six inches, while at this time the specimens seen by me are only half as large—are explicable in this way. I remark, however, that the American species are not commonly used as food, except by the French population of the Southern States.

But even aside from these abnormal instances, other younger and older specimens present quite a variable material for comparison and description. If you state, for instance, that the specific characters should be only taken from the full-grown specimens, this statement is not at all decisive, because it is impossible to determine whether a specimen be full grown or not. In Norway it is against the law to sell lobsters not full grown; and the law considers every lobster over eight inches long as full grown, because it is supposed to have spawned three times. But the lobster may become twice that size; it would then differ in sculpture, armature, and the relative size of its members, as mentioned before. The real difference is far greater, as it is reasonable to consider every lobster after its first spawn, although then much smaller, as a full-grown animal.

Although a good and complete description of a species should enable us to determine both the young and the full-grown specimens, still the

careful and right choice of the specific characters seems to depend largely upon the taste of the describer and upon the richness of the materials at his command.

Accidental Variations. — In the first place, all accidental variations are to be excluded. Crustacea are known very easily to reproduce parts damaged or accidentally lost; but these regenerated parts do not often reach the size or form of the old portions. Of course I do not here speak of variations, which are very easy to be recognized, as when one or more limbs are reproduced on one side. But I have seen specimens with the same limbs renewed on both sides, and such specimens, especially if one do not have before him more examples, are sometimes very difficult to recognize, and they often occasion errors (cf. *A. Gambelii*). The most prominent parts of the Crustacea are easily damaged and reproduced, as the claws, the antennæ and their basal lamina, the rostrum, and the caudal lamellæ. But sometimes the more protected parts are found affected in the same manner, as the first pair of abdominal legs, and even the epistoma.

Differences of Age. — The differences of age are of vast importance, and have a great influence on the right understanding of any species. The very young and newly hatched animals are, without doubt, recognizable by anybody. Afterward, as stated, there is more difficulty. The rich materials of the Museum allow the following remarks: —

Though generally the body has a constant form, I agree with Mr. Gerstfeldt, that even here there is no mathematical identity. The oval shape of the body, its greater or less convexity, its compression or depression, the abrupt or gradual curving of its sides, are somewhat variable. These variations, it is true, do not exceed certain limits; but they are here more troublesome, as in the great number of species they seem sufficient to obliterate the specific characters. I say expressly “seem sufficient,” as the greatest difficulty consists in expressing these differences clearly and definitely by words, while the worker, who sees the species before him, separates them more easily.

Differences in the Shape of the Head. — A more essential difference in the shape of the head and the great claws is to be found in specimens of different ages. Here these differences are more striking and more troublesome than the relations of the different parts. Their length and breadth, their thickness, compared with that of the body and its limbs, undergo marked fluctuations, and these fluctuations are far from being of the same kind in all the groups of our fresh-water Crustacea. In the several species of the group, of which *Cambarus acutus* is the type, the young animals always have a three-toothed rostrum, though in the older individuals the lateral teeth are often nearly or entirely obliterated. In the group of *Cambarus Bartonii*, on the contrary, the younger animals do not differ in the shape of the rostrum from the older, although

the limbs of the claw-legs are in their proportions sometimes very different in older individuals, the brachium longer even comparatively, the claw longer and thicker; the fingers more curved and furthermore separated from each other at the bases, while other similar differences are to be seen in the antennæ and their appendages, in the shape of the rostrum, and the front margin of the cephalothorax.

Differences in Sculpture.—The differences in the sculpture and armature are naturally much more considerable. The punctation, the granulation, the flat scales, the thorns, the spines, and the teeth, the margins of the thorax and of the great claws, are little or not at all developed in the younger specimens; they are a little more visible in the middle-aged animals; even those that are old and full grown sometimes differ considerably in the degree of development.

Hairyness.—On the contrary, the hairyness of some parts seems a constant character for species, even in the younger animals. But this character is to be found only in few species, and is not generally important.

Older Specimens.—On the whole, it may be said that in the older Astacidæ the form and the sculpture are more strongly exarated; the claw of the first legs is larger and heavier. But, besides the dimorphism of the males described further on, individuals are to be found in a so-called retrograde or arrested development.

Retrograde Development.—Older and larger animals are found, which in the degree of sculpture and armature are considerably behind specimens of similar or even smaller size, and these have apparently stopped at a lower stage of development. Naturally, these individuals are to be found mostly in the group in which the development of the sculpture and of the great claws is greatest, as in the group of *Cambarus acutus*.

Postabdomen.—The form of the postabdomen is constant in the different species; in the females it is usually broader. The external angles of the postabdominal segments are differently shaped, more or less rounded or acuminate. These differences are specific and constant, but usually they are not very remarkable, and they are difficult to describe. The “lamina analis,” especially the middle lamina, offers specific characters. Its basal part always has two or three teeth on each side of its front margin. But I must remark, that in shape and size, and even in number, the teeth are often variable. Nevertheless, when rich materials are at hand this character is useful. The form and especially the margin of the apical part of the middle lamina are likewise in some species different, and in some degree constant. I remark, as an example of the difficulty of recognizing occasional accidental variations, that I have seen of *Astacus Gambelii* but two males, one with the apical margin of the middle lamina exactly rounded, the other exactly notched. I consider the latter as perhaps accidentally altered.

Hands.—The hands, or great claws, are, in every description, carefully used as one of the best specific characters. No doubt their form and sculpture are quite different in many species, and offer characters most easy of recognition. Nevertheless, these characters become more and more uncertain as the materials in hand are richer. As I have stated before, the development, the size, and the sculpture of the hands vary considerably between the first and second form males and the females, between the young, middle-aged, full-grown, and gigantic specimens. Even the relative length and breadth differ; the brachium surpasses the eyes or not; the fingers are equal or unequal in length, longer than the rest of the hand or not, straight or curved, denticulated at the margins or not; the carpus has the spines more or less numerous, more or less developed. In the full-grown specimens the hands are surely a constant and good specific character, but even here they vary to a certain degree, and finally it is not at all easy, with scanty materials, to determine with certainty whether a specimen be full grown or not. Therefore I have never given in the different species the exact and detailed measurements of these parts, which are noted by some authors, as I have found these measurements of very little value. The measurements given by me are average measurements, generally of the most full-grown specimens. But I have always been careful to record all the different forms of the hands which I have observed in each species.

The hairyness of the hands, which, like a beard, a brush, or a pencil, is found in some species (*A. Gambelii*, *C. penicillatus immunis*, etc.), seems constant and a very good specific character; the same is true of the partial hairyness on the first pair of maxillary legs (outside and below, or outside only).

On the basal joint of the fourth and of the fifth pair of legs there occurs a little knob (capitulum), differing in its shape in given species in a constant manner.

Colors.—The colors are apparently of no value. I have not seen living specimens, but Dr. John Le Conte says directly: "All that I have ever seen were much of the same color," and "their color is generally lost with their life, so that it is of little value in the description." All the alcoholic specimens have a similar color, —reddish brown, inclining to a more or less dark olive or dirty yellow. In certain species red spots are occasionally to be found in some species, as noticed in my descriptions. I should remark that the color is apparently altered in alcohol as time advances. The specimens of *C. Bartonii* received within a few weeks are reddish brown, the older ones nearly yellow.

Dr. John Le Conte says expressly that the burrowing species do not differ from those that are aquatic.

THE SEXUAL PECULIARITIES OF THE ASTACIDÆ.

The sexual differences, aside from the genital parts, are often very considerable. In the female the great claw is shorter, smaller, and not so well developed. The sculpture and armature are less, the postabdomen mostly broader, and its legs stronger. Apparently the females have, in many parts, retained the characters of the younger animals. But sometimes there are females with a development not at all inferior, or with one even superior, to that of the males. I am not certain whether, as in the males, any dimorphism is to be found.

Abnormal Females.—It is not impossible in this way to explain, and thus indeed may be explained, many apparent anomalies in females. In these females we find a tendency to a more masculine development, as in the aforesaid males a tendency to a feminine development. Nevertheless, even the rich materials of some species now in my hands are not rich enough to enable me to solve by anatomical examination this interesting question.

The Abdominal Legs of the Males.—The sexual parts of the Astacidæ, especially in the North American *Cambarus*, offer very good and constant specific characters. The abdominal legs of the Astacidæ possess a short, transverse, inwardly situated basal article, and a longer doubled flagellum, consisting of two approximated narrow bands of a more membranous consistency, flexible, and sprinkled with hairs on the outside. In the males, the first and the second pair are partly transformed. The second pair has the basal half of the inner flagellum corneous and thickened, but the apical half retains the same membranous shape as the external flagellum and the flagellum of all the following legs. The corneous basal half is dilated at the end and rolled from the inside outward, forming a channel. The first pair of abdominal legs is even more transformed. The articulation between the basal limb and the flagellum is gone, and also the whole external flagellum, as well as the membranous apical part of the inner flagellum. The remains of the first abdominal leg form a corneous limb, with the apical half dilated and rolled from the outside inward, forming also a channel. This kind of shape is most easily understood in the true *Astacus* from Europe and from California. In the American species of *Cambarus* we find the modifications and different exarations forming, as stated before, very good specific characters. The dilated apical half is so closely rolled together that the channel no longer exists, except very superficially, and the closely rolled part is transformed into two approximate corneous solid cylinders, united above, while below there is an apparent suture, constituting the rest of the channel before described. The tip in each of the two cylinders is not simply truncated, as in the European and Californian *Astacus*, but transformed into more or less corneous

hooks and teeth. We find also in *Cambarus* the tip of the first abdominal legs bifid, and the two branches more or less elongated, equal or not in length and breadth, straight or curved, and very well adapted to form specific characters. Having examined a very great number of specimens, I am able to state that these different forms are very constant in the same species. Naturally here, as elsewhere throughout the group, it is not possible to find an exact mathematical identity, but a constancy within certain limits, and I was able to observe and figure some variations.

The rolled part of the second pair of abdominal legs—I have remarked before that it is rolled in the opposite direction—is apparently analogous to this formation in the first pair, and is formed in the European species exactly in the same manner as in the first abdominal legs. In the *Cambarus* the apical end of the dilated plate is considerably more rolled than the basal end, assuming in this manner a triangular shape. It is interesting to find the same arrangement in the true American *Astacus*.

The Purpose of this Structure.—The purpose of this structure of the first two pairs of abdominal legs is easily explained. The seminal fluid coming out of the basal part of the fifth legs by an open circular aperture, must be conveyed to the sexual aperture of the female, situated farther forward in the inner basal part of the third legs. The first pair of the abdominal legs of the male, being situated closer to the venter, is very well adapted by its channelled shape (represented in the *Cambarus* by the shallow suture) to direct the seminal fluid to the designed part in the female. It is likewise well to notice that the transformed shape of the second abdominal legs gives a considerable help for this purpose in two ways. First, the dilated part, especially in the *Cambarus*, is well adapted to be inserted into the sutured part of the first legs, and mechanically to support the first legs in a horizontal position. The rolled part also serves to complete the channel made by the first legs for the direction of the seminal fluid, and it is well to remark that the inverse manner of rolling, as before stated, serves more completely to prevent any of the ejected seminal fluid from taking a wrong direction. In the Madagascar and most of the Australian Astacidæ these modified abdominal legs, fitted for use in coition, are entirely wanting, and the conveyance of the seminal fluid is perhaps more simple and imperfect.

The Females.—Regularly in the articulated animals, especially in the insects, we find in the genera or families in which the organization of the sexual parts differs specifically in the males, that the females also exhibit differences more or less adapted to the male organs. The striking differences in the male organs of the *Cambari* made the presence of analogous differences in the females probable. But these are not to be found. The female sexual aperture is always

oval, closed by a thick membranous plate, firmly attached by the outside half, moving and opening inwardly. The oviduct is a simple hole, and, as far as I know, there are no specific differences. In a new gigantic Australian species of *Astacoides*, very near *A. nobilis* Dana the female aperture is more elongated and surrounded by a circular barbe of hairs, apparently designed for the better conveyance of the seminal fluid in a species without first abdominal first legs.

The manner of coition of the Astacidæ has been as yet rarely observed (Cuvier Règne anim., T. IV. p. 89, says: "L'accouplement s'opère ventre contre ventre"); but, on comparing closely the situation of the sexual parts of the male, it is evident that the first abdominal legs partly enter into the oviduct, and certainly no more than with their corneous tips. The length and situation of the parts, and the circumstance that the second pair of legs is apparently firmly fitted in coition to the first legs so as to prevent a farther entrance, seems to prove that perhaps this arrangement only serves to open the membranous plate of the female parts at the right time. In all the species of *Cambarus* the part of the first abdominal legs of the male, which may and which can only enter into the female aperture, is well marked and separated by a transverse superficial suture.

It is well known that the females of the Astacidæ possess no receptaculum seminis, and so the introduction of the seminal fluid seems without purpose. But as it is stated by Milne-Edwards that he once discovered spermatophores in the female aperture of *Carcinus*, which also has no receptaculum seminis, perhaps the same may occur in the Astacidæ.

Annulus Ventralis.—The female sexual aperture offers no specific characters, but we find some in the ventral, or rather sternal, plates between the last two pairs of thoracic legs, especially between those of the fourth pair. These differences not being very remarkable in the true *Astacus*, although they exist, I never find them mentioned by the authors. But the American *Cambarus* shows well-defined characters, although difficult to describe.

Between the fourth legs we find a broad trapezoidal plate, more or less excavated and elongated in the different species. The posterior end of this plate is ordinarily dilated and on every side angularly protracted. Its surface is smooth or tuberculated. Behind this plate is a supernumerary corneous organ (repeated even between the fifth legs), which gives specific characters. This organ—named annulus in my descriptions—generally forms a short cone, with a transverse oval base and a depressed tip. This cone is divided in the medial line of the body by a denticulated suture, with inflated margins. The tip is often more or less depressed, or even impressed, forming a deep, transverse hole, crossing the denticulated suture. Tab. II. f. 126.

We find inside two approximated, inflated, or vermiform ridges, fol-

lowing exactly the outside suture. The size of this corneous cone, and the shape of the suture and apical hole, differ considerably in the different species, and seem, to some extent, constant in the same species. The structure and shape of this organ seem to be for some sexual purpose. The ridges (in *C. acutus*, *Clarkii*, *Bartonii*, etc.) have an inner open entrance on the front margin, and seem opened between the suture outside on the hind margin. In the annulus I found fat and fibrous matter imbedded, and perhaps a glandular mass, which it was not easy to determine in the old alcoholic specimens. Nevertheless, the whole apparatus seems to be fitted for some secretion. Tab. II. f. 127.

The corneous cone in the species of *Cambarus* is well separated from the ventral plate, being only united to it by a membrane, movable in the young and sometimes even in the full-grown individuals. This is a specific character (*C. troglodytes*).

In the true *Astacus* this organ exists; still it is not separated from the ventral plate, except by an external channelled space; it forms a slender transverse ridge, varying in shape in different species, but not so conspicuously, and having no denticulated suture or secretional apparatus.

I have sometimes thought that this apparatus might perhaps serve for gluing the eggs to the abdominal legs; but as this does not exist in the true *Astacus*, it seems improbable. By what is possibly a singular coincidence, I have failed to find, among specimens from more than thirty localities and among several hundred females of all sizes, a single female, in the *Cambari* of the group *C. acutus*, with the eggs attached. Two females have young between the abdominal legs, but no remains of the egg-cases. Do the females of the group of *C. acutus* lay their eggs in a manner different from the other *Cambari*? I presume not.

Eggs: their Attachment and Bursting.—The eggs in the Astacidæ are always attached, as in some insects (in *Chrysopa*, *Hemerobius*, *Mantispa*), by a short stem. Before the appearance of the egg the glue is excreted from the female sexual aperture, fixed, and drawn out into a stem; finally the egg is fixed upon it. It is also to be presumed that the Astacidæ fix their eggs in the same manner. I should remark that the stem in the *Astaci* is always much stronger than in the *Cambari*.

It is, perhaps, interesting to notice that the eggs in the true Astacidæ are always burst in the same manner, viz. into two parts perpendicularly, the segments remaining attached to the stem. This condition makes it probable that the *Astacus* embryo has a particular egg-burster similar to that in the insects, although these interesting parts are little observed or known even by entomologists.

Development of the First Pair of Abdominal Legs in the Male.—It is easy to discriminate between the sexes of very young individuals of *Cambarus Clarkii*. This is the case with those only 0.3 inch long, and while they still occupy the postabdomen of the mother. In the females

the sexual aperture is visible at the base of the third set of legs. The first abdominal segment is without any appearance of abdominal legs; in all the other segments the abdominal legs are well developed, their length being nearly two thirds of the breadth of the postabdomen, the basal article being oblong, while the length of the doubled flagellum is a little greater.

In the males the first segment has on each side a little knob, somewhat longer than broad, turning inward. In the interior the developing leg is visible, and its articulation seems marked. This oval knob, with rounded tip, is the beginning of the first pair of abdominal legs. I have seen the same form of the first abdominal legs in the young of *C. Bartoni*, even 0.55 inches long. Tab. II. Figs. 133, 134.

Second Form of the Males.—I have examined the further development in *Cambarus acutus*. In the younger specimens, 1.7 inch long, the legs are more developed, the basal third articulated. The shape of the legs is nearly the same as in the full-grown animal, but narrower, more curved, the tip a little broader, the teeth more obtuse. In the older specimens, 2.7 inches long, the legs are the same as in the full-grown animal, which is over four inches long. Occasionally, both in younger and in full-grown specimens, the articulation is partly gone, but its remains are still visible on the upper margin; in some cases the articulation has entirely disappeared.

This form, which is always visible in the very young and in middle-aged specimens, ordinarily with an articulation, I have described as the second form of the male.

First Form of the Males.—In all species seen and examined by me, many old, full-grown males have the first pair of legs of a particular shape, analogous in a certain view to the form before described, and always found in the young animals, but differing in the following particulars.

The articulation is entirely gone; the tip of the leg is more distinctly finished and not so membraneous; the hooks are horny; the teeth or bifid ends longer and more separated; the hairyness, if any exists, more profuse. I have figured these parts in nearly all the species, and described them as the first form of the male. I think it is well to observe that, in the second form of the males, they are always developed in a manner visibly less complete than in the first form.

The males of the second form differ also in another way from those of the first form. The hooks on the third article of the third, or in some groups of the third and of the fourth, pair of legs are smaller and less developed. The whole body has less size and width, the sculpture is not so well finished, while the claws are shorter, narrower, and more like those of the female.

A closer examination of the rich materials at the Museum shows that

all the young male specimens of *Cambarus*, without exception, pertain to the second form. But there are also not a few large males belonging to the second form, which have retained the articulation and the shape of the tip of the first abdominal legs proper to the young specimens. The articulation is sometimes entirely or partially gone. Among nearly fifty full-grown males of *Cambarus acutus*, about twenty-five belong to the second form; while among fifty young males, nearly a dozen have, for the most part or entirely, lost the articulation. Tab. II. Figs. 112, 113.

The discovery that every species of *Cambarus* possesses two different forms of males was made by Professor L. Agassiz,* and kindly communicated to me.

Dimorphism, or perhaps a Sterile Form.—The existence of a second form of the male, if it were no more than a passage or metamorphic form, would not be extraordinary. But the great number of full-grown second-form specimens in every species, which are often even larger than the first-form males, seems to prove that they are individuals which have remained in a sexual stage that does not agree with their corporal development,—in short, that they are perhaps sterile.

The objection that these second-form males may be individuals shortly before or shortly after the casting of the skin I can surely refute, as I have seen many specimens at this stage of growth; the Museum collections exhibiting the animal in all the different phases of its existence.

Another objection, that the males of the second form, or perhaps those of the first form, are abnormally developed individuals, is refuted by the great number of the two forms existing and living together.

The conjecture, on the other hand, that the second-form males may be sterile, is really supported by the anatomical examination of the two forms in the principal groups of *Cambarus*.

Internal Sexual Parts of Cambarus Male. Of C. acutus. Tab. II. Figs. 120–123.—In two full-grown males of *Cambarus acutus*, first and second form, both four inches long, the testicles are trilobate, as in *Astacus fluviatilis*, but much smaller, the vasa deferentia shorter. In the first-form males the two superior lobes are pyriform, truncated above, united below in a membraneous hole a little shorter than the testicles, and connected with the third inferior lobe. Where the two superior are united, the vas deferens begins on each side, being vermiform and shorter than the body. The testicles in a *Cambarus acutus*, four inches in length, are but 0.3 inch long; while in an *Astacus fluviatilis*, two inches in length, they are 0.6 inch long, thus much larger,

* Intending many years ago to describe the North American Astacidae, he made a close inspection of the material he had collected for that purpose. Observing the different shape and organization of the first pair of abdominal legs, he was led to this important discovery.

and there is no membranous hole, as the three lobes are closely approximated; the vasa deferentia are also stronger, more curved, and have greater length than the body. Their end is visibly more dilated than in *Cambarus acutus*.

In the second-form male of *Cambarus acutus* the testicles are similar but smaller, the superior lobes narrower, oval; the inferior lobe is acuminate, narrower, and not bigger than the connecting hole of the superior lobes. The vasa deferentia are shorter. The microscopic examination of the contents of the testicles offers no further argument, as the specimens have remained too long in alcohol.

Of *C. virilis*. Tab. II. Figs. 128–132.—In the first-form male of *Cambarus virilis*, 3.2 inch long, the testicles are somewhat similar, but longer, being in length 0.7 inch. The superior lobes have a prismatic form, with diverging acuminate ends. The prismatic part is excavated above, and much separated from the smaller and compressed hole. The inferior lobe is long and compressed, seen sidewise, oval, and truncated behind. The vasa deferentia are longer than in *Cambarus acutus*, while their ends are not visibly dilated.

In the second form of *Cambarus virilis*, 2 inches long, the testicles are shorter, the superior lobes prismatic, but the superior part is not much separated; the inferior lobe is shorter, beginning with a narrow hole, laterally more compressed; the vasa deferentia are shorter and narrower.

Of *C. Bartonii*. Tab. II. Figs. 135–138.—In the first form of the third principal group in *Cambarus Bartonii*, 2 inches long, the sexual parts are more similar to those of *Astacus fluviatilis*. They are 3.5 inches long, the superior lobes oval and large, while their superior tip is a little contracted. Connected by an inferior, well-separated, smaller membranous hole with the equally long hole of the inferior lobe, there is to be found behind the connecting joint an inflated tubercle, while lower down there is another which is similar but smaller. The inferior lobe is pyriform, inflated behind, somewhat compressed laterally. The vasa deferentia are stronger and longer, the ends being visibly dilated.

In the second-form male of *Cambarus Bartonii*, 2 inches long, the testicles are shorter, the superior lobes more trigonal, the inferior narrower, elongated, much more compressed, acuminate behind, the connecting holes not so well separated and finished, without tubercles behind, while the vasa deferentia are narrower and shorter, the ends not being visibly dilated.

I may remark, that in the first-form males of *Cambarus acutus* and *Bartonii* the three lobes of the testicles exhibit the same granulated contents as in *Astacus fluviatilis*. But in *Cambarus virilis* they are white and have a fatty appearance, similar to those always found in the second-form males.

The sexual parts of the second-form males are so much less developed that it would be allowable to consider them as sterile. An anatomical examination of the second-form males without articulation in the first abdominal legs was not possible, as the materials were not sufficiently abundant.

As before stated, I surmise the presence of similar sterile females; which as viragoes show more of a male type.

An anatomical examination of the females of *Cambarus acutus* and *Bartoni* reveals some difference in the shape of the ovarium.

Internal Sexual Parts of the Cambarus Female. Of C. acutus. Table II. Fig. 123.—In *Cambarus acutus* the ovarium is nearly an inch in length, elongated, narrow. The two superior lobes are shorter, cylindrical, a little inflated at the base; the inferior lobe is elongated, conical. The connecting part is more enlarged, and gives on each side a large oviduct. Above this part is situated a strong membrane, which passes with an acuminate tip between the superior lobes; it is provided laterally with some bands of “musculi alati,” while the fibres are strongly striated transversely. This membrane also shows several nerves, apparently belonging to the nervus sympathicus.

Of C. Bartoni. Table II. Fig. 129.—In *Cambarus Bartoni*, 2 inches in length, the ovarium is 0.65 inch long, and larger. The superior lobes are shorter and oval; the inferior a large cone. The oviduct is even broader. The membrane is similar to that in *Cambarus acutus*. In both species examined, the ovarium was filled with eggs of different sizes and degrees of development.

No Dimorphism in the true Astaci.—The existence of two forms of males in the *Cambarus* of North America has been proved by me in all species in which I was able to examine a large number of specimens. In five species, represented only by single specimens of first-form males or females, I have not seen the second form. But the existence of this second form will be by far the more interesting, since it seems that in the *Astacidæ* only the *Cambarus* possesses two forms of the male. I have examined nearly two hundred specimens of *Astacus fluviatilis* from different European localities (Germany, Switzerland, France, Scotland), without finding a difference in the males. I must add that I have not seen very young specimens, and do not know at all whether the young have the first pair of abdominal legs articulated as in the *Cambarus*. The smallest specimen seen by me is 1.5 inch long. Of the Californian *Astaci* I have not seen more than a dozen males. All these were quite full grown, and without any differences answering to the second form of *Cambarus*. Of the Amur species I have seen but one female.

Dimorphism in other Crustacea.—Perhaps this fact of the existence in the crustacea of two forms, one always sterile, is not unique. In the

genera *Lupa* and *Callinectes* there are not rarely females with a very narrow and acute postabdomen. These it is very easy to separate from the ordinary females, with large and circular postabdomen. Professor L. Agassiz informs me that he has satisfied himself, by an anatomical examination of living specimens, that these females are sterile. I have found similar females with a narrower triangular abdomen in some other genera of *Brachyura*.

I am indebted to Mr. Alexander Agassiz for the information that F. Müller, Fuer Darwin, 1864, has described two forms of the male in *Orchestia Darwinii* and in *Tanais dubius*. He remarks that when found upon the shore the form of the second pair of gnathopoda varies from that of specimens found at a distance inland, where it lives under mouldy leaves in loose earth. In *O. Darwinii*, intermediate forms between the males with large and those with small hands are not to be detected, but in two other species, *O. tucurauna* and *O. tucuratinga*, the shape of the antennæ and of the hands changes even in the full-grown males.

The supposition that the first-form males only in *Cambarus* possess large hands for burrowing purposes is to be rejected, as the females also have the same burrowing habits.

The existence of two different forms of males in *Cambarus* is very important in the description of the species, and the fact that these forms are not recognized by all preceding authors may explain some erroneous determinations in their works.

Dimorphism in Insects.—The discovery of a dimorphism in the crustacea is all the more interesting, since as yet in the whole animal kingdom dimorphism was known only in the insects. There are many facts and communications scattered through entomological literature, of which a general review is very desirable. An anatomical examination of these dimorphic forms is still wanting, only the external differences having been thus far marked.

The dimorphism seems to be represented in two different ways; a difference only in the colors (dichroic forms of Brauer), or a difference in size and shape, and mostly in the female. I should remark that dimorphism, as observed in insects, occurs only in one sex of the same species, and mostly in the female. Perhaps in the ants and in the white ants—it seems more natural to range all the socially living insects, viz. the ants bees, wasps, and white ants under the same law—a dimorphism is to be found in both sexes.

Dimorphism consisting in different colors was long since observed, especially in Lepidoptera, in the hind wings of many Orthoptera, and in the females of Agrion. In the latter genus the well-known orange-colored females are probably sterile.

Dimorphism with difference in shape and size is also often observed. A very common case is the difference in the development of the wings.

The wings are either long and well developed, or short, or entirely wanting. The short-winged Orthoptera (*Gryllus*, *Locusta*, *Blatta*, *Perla*, *Termes*, *Psocus*) have been carefully described by Messrs. Fischer, Von Siebold, Lucas, Brauer, and myself; the short-winged or apterous Hemiptera, by Westwood and Uhler (*Amphibiocoris*æ, *Gerrid*æ, etc.); the short-winged Diptera by Schaum (*Ornithobia* and *Lipoptera*). Mr. Brauer has recently given an interesting paper upon dimorphism in the genus *Neurothemis*, which belongs to the Odonata. The dimorphic females have wings with a less complicated neuration and different colors. There is even a case of trimorphism in some butterflies, according to the observations of Mr. Wallace. *Papilio Ormenus*, from Celebes, has three distinct forms of females, and in some cases the number of female forms appears to be four. Dimorphism consisting in different shape and size is observed in the Lepidoptera (*Equites*, etc.), in the Coleoptera, in the Lamellicornia, and in the Longicornia, and perhaps in the Lymexylon and Hylecoetus; in the Hymenoptera (*Cynips*); in the Diptera (*Phasia*). The dimorphism in the Dipterous genus *Phasia*, discovered by Loew, is very remarkable. Having seen his specimens, I may be permitted to add here a written communication by Mr. Loew, sent to me some years ago and still unpublished: "In the genus *Phasia* every species has two male forms; one similar to the female, and another much larger, with the wings broader and more colored, and usually the body more colored. The two forms fly at the same time and unite with the same form of females. The genital parts of the larger males are in shape and size identical with those of the smaller males. There exist some intermediate forms of males, and it is sometimes, in certain species, possible to form a complete series, which seems to unite the two different forms. I say seems, because I have never seen a male which I hesitated to place in one of the two forms."

I have noticed here the occurrence of dimorphism in the insects to show how variable in the different families and genera is the mode of dimorphism, even from that observed in the *Astacid*æ. Perhaps a closer examination will disclose even some difference in the sexual parts in certain dimorphic insects, and it now seems probable that some forms, heretofore described as distinct species, will be hereafter recognized as only dimorphic variations. Still, it is possible that very different facts are to-day united under the same name of dimorphism.

Certainly the discovery of a dimorphism in another part of the Articulate, viz. in the Crustacea, leads us to suppose that it will be found also among the worms.

The Rarity of Varieties is an Important Character for Cambarus. — The rarity of varieties in the genus *Cambarus* is worthy of remark, and may be considered as an important character of this genus. In the true *Astacus*, the two species living in Europe vary so much that even by

eminent naturalists these varieties have been taken for nine different species. In the genus *Cambarus*, the thirty-two known species show comparatively very few varieties. But of three of these, viz. *C. acutus*, *C. virilis*, and *C. Bartoni*, the described varieties differ in a more considerable manner; while perhaps some of them, especially of *C. Bartoni*, will be hereafter recognized as different species. Indeed, the fact is too striking to be overlooked; here there are few species and many varieties, there many species and few varieties.

CAMBARUS ERICH.

The question, Is *Cambarus* a peculiar genus different from *Astacus* or not, is one of great importance to me as monographer. The historical statements already quoted are all that have been made, so far as I know, upon the subject. It would no doubt have been more easy for me to judge of the importance of the generic characters if I had been able to study in the same manner all the species of the old genus *Astacus*. But the materials before me, except for North America, are not sufficient; some genera are entirely unrepresented, of others only a few specimens are at my disposal. I therefore confess that my judgment upon a division of the old genus *Astacus* into more genera is not completed; still, after a rather close examination, I am convinced that *Cambarus* forms a very good and natural genus, and that, if it be not accepted, a very great part of the actually adopted genera must be equally rejected.

The differences between *Astacus* and *Cambarus* are as follow:—

1. The general form of *Astaci* is clumsier, coarser, and more oval. The *Cambari* are more elongated and more cylindrical.
2. The absence of the gill on the fifth pair of legs in *Cambarus* is first quoted by De Haan. *Cambarus* has seventeen, *Astacus* eighteen gills. But there is also another difference, not before noticed. In *Astacus* each pair of gills, except the single one on the fifth set of legs, has a broad, deeply folded membrane, closely fixed behind the most external gill lobe. In *Cambarus* this membrane is always wanting in the gills on the fourth pair of legs, but exists, as in *Astacus*, in all the others. In the true *Astacus* all the gills with a folded membrane behind have a basal external bundle of shorter but broader and irregularly placed gill tubes; these are never to be found in *Cambarus*. The superior external plate of the fifth pair of legs in *Cambarus* is surrounded by longer featherlike hairs; in *Astacus* we find but few on the posterior border; *C. pellucidus* is similarly organized to the true *Astacus*.

I may remark that the breadth of the areola or the medial postdorsal region (Dana) seems not to depend, as it would be easy to suppose, upon the presence or absence of the gills on the fifth pair of legs. We

find in some *Cambari* (*C. spiculifer*, *versutus*) this areola even as broad as in many true *Astaci* with gills (*A. Klamathensis*, *Gambeli*), but in general the areola is never so well marked in *Astacus* as in *Cambarus*.

3. The inner antennæ in *Astacus* have a peculiar structure and shape. They are always very short and more conical (the basis thicker); the inner flagellum is considerably more slender and shorter, while the joints of the flagellum are more spherical, calcareous, and more fragile. Of course the inner antennæ are easily broken in the preserved specimens. In *Cambarus* the inner antennæ are visibly longer, the flagellum is equally long, and of the same structure as the outer antennæ.

The lamina of the outer antennæ has a prismatic shape in *Astacus*, the external border is much thickened. In *Cambarus* the lamina is visibly more membranous.

The basal article of the inner antennæ has an anteapical spine beneath in *Astacus*; in *Cambarus* this spine is always situated in the middle of the article, or more basally.

4. The epistoma in the true *Astacus* is more solid, conical, a little contracted before the tip. It is in *Cambarus* more flattened, often excavated beneath, always larger, and never contracted before the tip.

5. The ear, or what is considered the auditory organ, forms in *Cambarus* (as in *Astacoides*, *Homarus*, and perhaps in *Cheraps*) a very short cone or a slightly elevated ring, closed above by a membrane, considered as the tympanum. The true *Astaci* are an exception, and have this organ differently shaped, with a more elevated cone, rounded on the top, and a narrower tympanum behind.

6. The parts which serve for sexual purposes in *Cambarus* differ essentially from those in *Astacus*. In *Cambarus* these parts are organized in a particular manner, and differently in every species. This is very important, as it is well known that in the Articulata very nearly allied genera often differ constantly in such a manner. This difference seems a criterion for separating two genera in forms otherwise nearly related.

These differences are as follow: Dimorphism is to be found in the males. The first pair of abdominal legs is differently formed; the apical half is not simply rolled as in *Astacus*, but transformed into two solid approximated parts, with the tips more or less protracted and differently finished.

In the females is to be found behind the sternum, between the fourth (and fifth) pair of legs, a particular separated part, — annulus, — differently shaped in the different species. In *Astacus* this part exists indeed, but it is never separated from the sternum, and is represented by a ridge, either straight and transverse or curved and broken behind. The particular shape of the annulus in *Cambarus*, with its denticulated median suture and its transverse hollow impression, is evidently anal-

ogous to the form in *Astacus*, but produced in a different and exaggerated manner. The hinder part of the sternum is separated and curved, not backward, as in *Astacus*, but forward and entirely rolled.

I may remark that, according to my anatomical investigations into some species, the internal sexual parts in males and females of *Cambarus* differ from those in *Astacus*. The three lobes of the testicles and the ovarium are larger, rounded, and closely approximated in *Astacus*, the vasa deferentia longer than the body. In *Cambarus* the three lobes are small, elongated, and separated; the vasa deferentia shorter than the body.

It would be very interesting to prove that the young of the genus *Cambarus* are hatched from the eggs in a similar but more advanced stage of development than the young of the genus *Astacus*, described by Professor Rathke. But the materials in my hands are not sufficient for this purpose, the smallest seen by me being 0.3 inches long, and belonging to *C. Clarkii*. The rostrum is incurved, but always tridentate; the interior antennæ have the flagellum short, and the exterior branch visibly thicker than the interior. The three anterior pairs of legs have nearly the same shape, the first pair is a little longer. The appendage to the legs of the young lobster, described by Thompson, Rathke, and others, does not exist at all. The abdominal legs do exist. The hooks on the third and the fourth pair of legs of the males are not developed. It is easy, as I have before intimated, to discriminate between the two sexes. The eyes are visibly more developed than in the more advanced animals.

With reference to the further division of the genus *Cambarus*, it was especially important to decide whether all North American *Cambari* belonged to the same genus or to different genera. I am now convinced that all the species I have seen form only one genus, containing several more or less well-defined groups. In this manner the genera *Cambarus* and *Astacus* seem very natural and of equal value. But I have no doubt that some time the genus *Astacus* will be divided into three genera (for the European, North American, and Asiatic species), and *Cambarus* into three or it may be into six genera as Prof. Agassiz thinks.

The division of *Cambarus* into groups is not difficult, except in a certain view: first, as the most striking characters are to be found only in one sex, in the males; and secondly, as some species seem to form a sort of medium uniting the different groups. The first objection is only of value to the naturalist who works with few materials, perhaps mostly females, and is therefore not able to determine the groups to which his specimens belong. But here the fault lies only in the scantiness of his materials, and not in the principle of classification. The second objection would be more important if it were quite certain that there are intermediate species. Perhaps these species only seem to be inter-

mediate, and if not, finally, Nature never agrees with the strict principles of a particular scheme, so that apparently capricious aberrations are to be found everywhere the stumbling-blocks of the naturalist who wishes to arrange everything in a regular series.

A principal character suggesting the division of *Cambarus* into groups is to be found in the hooked legs of the males. This character divides all the species into two great groups, one with hooks on the third and the fourth pair of legs, the other with hooks only on the third pair of legs. This characteristic seems preferable to the later mentioned one, because it unites forms which are related in all other respects, while the groups divided according to the form of the rostrum unite species which are otherwise quite unlike.

In number and situation the hooks are always identical and very sure. Among nearly a thousand males I have found only one abnormal male with no hooks at all. I have never observed any aberration in the group with hooks on the third and on the fourth pair of legs, except a few second-form males of *C. pellucidus*, with the hooks on the fourth legs very small, even in one case not at all developed. In the other group, with hooks on the third set of legs, sometimes, but very rarely, males are to be found with hooks more or less developed on the second pair of legs, but never on the fourth pair. I may add, that the second-form males always have less developed hooks, and that all show the hooks except the very young and newly hatched males.

It is worthy of remark, and seems to prove the importance of this character, that the hooks are situated on the same joint and at the same place as the embryonal appendages of the legs in the young lobsters (*Homarus*), described by Professor Rathke and others. These afterward disappear, and are not to be found at all in the young of *Astacus fluviatilis*. Indeed, these hooks do not exist in the young *Cambari*; their development is later; but the analogy is too striking to be overlooked, and suggests the great desirableness of an accurate acquaintance with the embryological development of *Cambarus*.

According to the number of hooked legs, *Cambarus* is also divided into two groups:—

I. Third and fourth legs hooked, — group of *C. acutus*.

II. Third legs hooked, — all the rest.

The second important character for the division of *Cambarus* into groups is the shape of the rostrum. Mr. Girard has employed this character as a principal one, and forms three groups, with the following characters:—

Rostrum subquadrangularly elongated, tridentated at the tip, — *C. affinis* and allied species.

Rostrum short, broad, conical, toothless, — *C. Bartoni* and allied species.

Rostrum very much elongated, conical, with a small and acute spine

near the extremity, sometimes, however, but very slightly developed, — *C. acutus* and allied species.

This character is indeed good, but sometimes not so striking as to prevent a mistake, which even Mr. Girard himself made, in placing *C. pellucidus* in his first group. There are some species in every group, the exact place of which is uncertain. At first sight the *C. spiculifer* and *C. versutus* would be placed in the first group, and not in the third; *C. penicillatus* and *C. Wiegmanni* near *C. Bartoni* in the second group, and not in the third; *C. immunis* in the second, and not in the first; *C. advena* and *C. Carolinus* in the third, and not in the second, — to which in reality they respectively belong. But generally, I repeat, this character is good, if not *prima vista*, at least in connection with the other characters.

Nevertheless, in the rostrum is to be found another important character. In one group the rostrum never has lateral teeth at the tip, in all others these lateral teeth are to be found, if not in the full-grown specimens, yet always in the young. But the latter fact renders this mark evidently less useful than the character taken from the hooked legs. In the last case only the newly hatched specimens have no hooks and are doubtful; but in the other instance only the newly hatched specimens always have teeth, while the full grown are sometimes toothless. *C. acutus* and the allied species always have in the young specimens well-developed teeth, and the form of the rostrum is therefore altered in such a manner as to place them *prima vista* in Mr. Girard's first group, near *C. affinis*. *C. penicillatus*, though toothless when full grown, has well-developed teeth when young. *C. immunis*, and in some degree *C. virilis*, *C. propinquus*, and others, are in the same condition.

According to the absence or presence of the lateral apical teeth of the rostrum, *Cambarus* is divided into two other groups, not coinciding with those already mentioned: —

I. Always toothless, — *C. Bartoni* and allied species.

II. With teeth, at least in the young, — all the rest.

Combining the two principal characters mentioned, — the number of the hooked legs and the toothless or toothed rostrum, — we find three well-defined groups: —

I. Third and fourth legs hooked, rostrum toothed, — *C. acutus* and allied species.

II. Third legs hooked, rostrum toothed, — *C. affinis* and allied species.

III. Third legs hooked, rostrum toothless, — *C. Bartoni* and allied species.

These groups coincide with those established by Mr. Girard, after removing his erroneously placed species, viz. *C. pellucidus*, *C. Oreganus*, *C. Gambeli*.

Some other characters serve to evince more or less clearly the naturalness of these groups.

The first abdominal legs of the males show three different forms:—

I. The exterior part is nearly truncated at the tip, with three little partly dilated corneous incurved teeth; the interior part has a short acute tip, for the most part outwardly directed,— *C. acutus* and allied species.

II. The two parts have elongated, straight, acute tips,— *C. affinis* and allied species.

III. The tips of the exterior part forms a larger tooth, which is strongly recurved; the tip of the interior part is broken, short, and conical,— *C. Bartoni* and allied species.

I may remark that there are three exceptions to this character: *C. extraneus*, belonging to the group of *C. affinis*, has the abdominal legs formed as in the group of *C. Bartoni*; *C. advena* and *C. Carolinus*, belonging to the group of *C. Bartoni*, have the abdominal legs similar to the group of *C. acutus*.

The other characters examined by me are not so striking. The antennæ are more slender, as long as, or longer than, the body in the group of *C. acutus*; they are thicker and mostly shorter in the others. In *C. acutus* and the allied species the flagellum of the inner antennæ is longer, while its branches are equally long. In all the other species the flagellum is shorter, and the external branch somewhat longer, than the inner. The antennal lamina is more elongated and enlarged before the middle in the group of *C. acutus*; shorter and enlarged near to the tip in the group of *C. Bartoni*; longer and enlarged in the middle in the group of *C. affinis*. But here are to be found more numerous exceptions,— *C. pellucidus*, *C. Wiegmanni*, *C. Carolinus*, *C. lancifer*, etc., lack the form characteristic of their group.

CAMBARUS. — *Corpore elongato; pedibus quintis branchiis nullis; antennis internis flagello longiori; auro annulari, apice aperto; pedibus maris tertius, vel tertius et quartis articulo tertio unguiculatis; pedibus abdominalibus maris bifidis; femina annulo ventrali conico, perforato, separato.*

I. GROUP. (TYPE, *C. ACUTUS*.)

The third and the fourth pair of legs of the males hooked; rostrum triangular, elongated, with an ante-apical tooth each side, at least in the young; first pair of abdominal legs with the exterior part truncated at the tip with several somewhat dilated incurved corneous teeth, occasionally covered with a pencil of hairs; the interior part terminated in a short, acute, and for the most part outwardly directed spine.

This group seems very natural, if we except some abnormal species, viz. *C. penicillatus*, *C. Wiegmanni*, and especially *C. pellucidus*.

The body and the hands are more slender and elongated. The flagellum of the inner antennæ has the branches of equal length. The

length of the antennæ equals that of the body, or exceeds it; their lamina is elongated, and dilated near the base; the basal joint of the inner antennæ has an inferior spine before the middle. The foreborder of the cephalothorax is angulated behind the antennæ.

In *C. troglodytus* burrowing habits are observed.

It is worthy of remark that in the considerable number of females seen by me, eggs are in no instance attached to the abdomen. Perhaps the females live more retired now than formerly, and are not easily secured. I have seen many females of various species of the other groups with eggs attached to the abdomen.

The species contained in this group are divided into four natural sections, having the following characters:—

1. The rostrum is broad, very long, triangular, with a small spine near the extremity, somewhat, but very slightly, developed (always strongly developed in the young); the postabdomen is as long as the thorax; the hands are elongated; the antennal lamina is long, and enlarged near the base,—*C. acutus* and allied species.

2. The rostrum is broad, very long, triangular, with a strong and acute apical tooth on each side; the postabdomen is longer than the thorax; the hands are elongated; the antennal lamina is long, and enlarged near the base,—*C. spiculifer* and allied species.

3. The rostrum is broad, triangular, not so much elongated, without ante-apical teeth (always developed in the young); the postabdomen as long as the body; the hands are shorter, broader; the antennal lamina is shorter, and enlarged near the tip,—*C. penicillatus* and allied species.

4. The rostrum is broad at the base, very long, with a strong and acute tooth each side; the postabdomen is longer than the thorax; the hands are elongated; the antennal lamina is long, and much enlarged near the tip,—*C. pellucidus*.

The most aberrant species is *C. pellucidus*. Like the other animals living in caves, it is blind. The eyes are atrophied, smaller at the base, conical, instead of cylindrical and elongated, as in the other species. The cornea exists, but is small, circular, and not faceted; the optic fibres and the dark-colored pigments surrounding them in all other species are not developed. The shape of the rostrum is somewhat analogous to that of *C. affinis*, the margins are more parallel at the base. The lamina of the antennæ is long, but strongly dilated nearer to the tip; the epistoma is shorter and broader than in the other species; the basal joint of the inner antennæ has a spine at the tip, which in the other species is always nearer to the base; the foreborder of the cephalothorax is not angulated behind the antennæ as in all other species.

Nevertheless, the number of the hooked legs, the form of the abdominal legs, and the elongated body and hands, exclude *C. pellucidus* from

the other groups. Some, no doubt, will prefer to regard *C. pellucidus* as a distinct group or genus, still, as I am convinced, without foundation. The most striking differences consist in the aberrations in the shape of the fore parts and of the limbs of the head. But it seems to be a somewhat well-recognized law in nature (Rathke, *Metamorph. Retrograd.*, p. 125) that if any part is atrophied, or stopped in development, the nearest parts show an abnormal increase of development. This is apparently the case in *C. pellucidus*; the eyes are atrophied, and the rostrum, the fore border of the cephalothorax, the antennal lamina, the basal joint of the inner antennæ, and the epistoma are altered or largely developed.

Similar alterations are not rarely noticed in the insects. The blind soldiers of *Termes* have the head and the mandibles more developed, the maxillæ and the labium atrophied. Analogous facts are observed in the ants and in the two very nearly related Coleopterous species, *Hylecæthus dermestoides* and *flabellicornis*. In *H. dermestoides* the antennæ are simple, the maxillary palpi extraordinarily developed; in *H. flabellicornis* the antennæ are much developed and the maxillary palpi simple. It would not be difficult to give a greater number of similar examples.

The two species of the third section are not as abnormal as *C. pellucidus*, and they differ only in the two characters before mentioned.

SYNOPSIS OF THE SPECIES.

1st SECTION. (See p. 33.)

- a. *Epistoma* rounded in front: *C. acutus*, *C. Blandingii*.
- b. *Epistoma* truncated in front: *C. Clarkii*, *C. troglodytes*.

2d SECTION. (See p. 33.)

- a. *Areola* narrow: *C. fallax*, *C. LeContei*.
- b. *Areola* broad: *C. spiculifer*, *C. angustatus*, *C. versutus*.
(*Incertæ sedis*.): *C. maniculatus*.

3d SECTION. (See p. 33.)

- C. penicillatus*: *C. Wiegmanni*.

4th SECTION. (See p. 33.)

- C. pellucidus*.

1. CAMBARUS ACUTUS *Girard*.*Cambarus acutus* Girard, Proc. Acad. Philad., T. 6, p. 91.

Figures on Pl. I., II., and III.

First abdominal legs of the male :

first form, fig. 1 in front ; fig. 2 outside ; fig. 108 outside viewed more laterally ; fig. 106 inside.

second form, fig. 4 in front ; fig. 3 tip augmented ; fig. 5 outside.

fig. 110 outside, young, 1.7 inch long ; fig. 111 outside, 2.7 inches long.

fig. 112 outside, 2.7 inches long, not articulated ; fig. 113 outside, 1.4 inch long, not articulated.

var. A, first form, fig. 107 inside ; fig. 109 outside.

Venter between the fourth pair of legs of the female, fig. 114, *C. acutus* ; fig. 115, var. A.Rostrum, fig. 116, *C. acutus* ; fig. 117, var. A.Epistoma, fig. 118, *C. acutus* ; fig. 119, var. A.Thoracic line, fig. 124, *C. acutus* ; fig. 125, var. A.

Inner sexual parts of the male :

first form, fig. 120 ; testicles viewed from above, fig. 121.

second form, fig. 122.

Inner sexual parts of the female, fig. 123.

Annulus ventralis of the female, fig. 126 outside ; fig. 127 inside.

Antennal lamina, fig. 143, *a* ; epistoma, *b* ; spine of the second joint of the exterior antennæ, *c* ; fig. 144, the same parts for var. B, from New Jersey.

MAS. Rostro triangulari, lato, dimidio longiori, subdeflexo, ante apicem brevem acutum utrinque subsinuato, margine punctato-lineato ; supra lævi, subexcavato, basi late foveolato ; cretis basalibus extus sulcatis, apice subacutis, fere parallelis, postice callosis convergentibus. Antennis externis corpore æqualibus vel longioribus, articulis duobus basalibus dente externo brevi, subacuto ; antennis internis articulo basali ante medium dente infero, acuto ; lamina externa rostro longiori, antennarum pedunculo æquali, lata, apice rotundata ; margine externo inflato, apice brevi-spinoso. Epistomate brevi lato, excavato, antice rotundato. Pedibus maxillaribus externis intus et subtus barbatis. Thorace postice latiori, densius tuberculato ; cephalothorace supra fere lævi, parce-punctato, postice obsolete bicalloso ; linea profunda, sinuata, lateribus divisa, spina infera ad antennarum basin apicali, modica ; areola angusta, carinata, postice latiori, plana, interdum transverso-impressa ; margine postico subexciso. Postabdomine lato, apicem versus subangustiori, lævi, parce-punctato, segmentis utrinque macula obsoleta rubra ; segmentis penultimis angulo externo postico recto ; lamina media parte apicali breviori, apice rotundata, margine medio exciso ; parte basali apice utrinque bispina. Pedibus anticis valde elongatis, corpore interdum longioribus ; chela longa, angusta, modice tumida, squamoso-tuberculata ; margine interno longo, subrecto, fortiter dentato ; digitis longioribus, interno sublongiori, supra planis, subtus medio elevatis ; externo recto, interno sinuato ; digitis basi tuberculatis, externo tuberculo medio et basali interno ; interno basi intus exciso, margine externo basi tuberculato. Carpo longo, latere interno

tuberculato, margine interno spinis duabus, antica majori; subtus spinis majoribus duabus anticis, aliisque minoribus internis. Brachio elongato, rostro longiori, extus lævi, intus ante apicem et margine supero tuberculato, spinis duabus anteapicalibus oblique positis; subtus biseriatim spinoso. Pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis et quintis capitulo basali, quartis elongato-ovali, quintis compresso, laminato. Pedibus abdominalibus brevibus, rectis, validis, apice vix-bifidis; parte externa majori, apice barbata, dentibus tribus fusco-corneis, subincurvis; parte interna dente apicali acuto, obliquo, partem externam fere superanti.

Forma II. differt unguiculis pedum minoribus; pedibus abdominalibus basi articulatis, parte externa fere obtusa, dentibus obsoletis; parte interna dente apicali crassiori, conico.

Mares formæ secundæ variant sæpe brachio rostro breviori, interdum chelis brevibus, valde angustis, digitis rectis, lævibus; rostro forma variabili, latiori, marginibus rectis vel subincurvis, acumine angustiori, utrinque magis sinuato.

Femina differt pedibus anticis chelisque brevioribus, extus lævioribus; ventre inter pedes quartos antice tuberculo majori, postice bi-vel bisbituberculato; annulo ovato, fissura longitudinali, labiis alternato-inflatis. Chela interdum basi rubro-maculata.

Variet. A.

A great number of specimens from Illinois (Lawn Ridge, Basson Ridge, Evanston, Athens, and Peoria) and from Indiana (Mus. Salem), comprising both forms of the male and the female, which differ as follows: The rostrum has the margins not so arcuated at the base, the margins are more straight; the epistoma is often more pointed; the transverse line of the thorax is less sinuated, but usually with a lateral spine. The shape of the first pair of abdominal legs is different; seen sidewise the apex more dilated, not hooked behind, the apical teeth are a little larger, and pointed. The female has the ventral segment between the fourth pair of legs not bituberculated, but with a slightly elevated carina; the ventral segment between the fifth pair of legs is more sharply pointed, its articulation-membrane reaching farther to the tip of the base of the abdominal legs. The hands often have large red basal spots.

I have seen very full-grown females, the males not so full grown as those from New Orleans.

Varietas ? B.

I have seen six adult females from Essex, New Jersey; New York; and Beaufort, North Carolina. At first they seem to belong to another species. The lamina of the antennæ is much smaller at the tip; all have a lateral thoracic spine; the rostrum appears narrower in front

of the tip; the tip is more sinuated, with sharper lateral teeth; the hands are smaller and smoother; the femur is not tuberculated on the inner side. But a closer examination of many young and old specimens from the South shows so many analogous forms, that it is impossible, at least as yet, to separate them with certainty. But I confess that they seem, in many respects, to belong to a different species (viz. *C. Blandingii*). Long. corp. 3 ad 4 inch.

Mas maximus long. corp. 6.3; antenn. 5.1; ped. ant. 6.2; chelæ, 3.9.

Patria: New Orleans and Milliken's Bend, Louisiana; Mobile; Charleston, South Carolina; St. Louis, Mississippi bottom; James River, Virginia (Mus. Philad.); Mobile River; Kemper Co., Mississippi (Mus. Philad.).

Var. A. Lawn Ridge, Basson Ridge, Evanston, and Peoria, Illinois; Indiana (Mus. Salem).

Var. B. New Jersey; New York; Beaufort, North Carolina.

Vidi specimina plurima, adulta et juniora.

I have not seen the type of *C. acutus* Gir., but I have no doubt that it is the first form of the species described above. The Museum of Philadelphia possesses two young dry second-form males, labelled "*C. acutissimus* Gir.?" from Kemper Co., Mississippi, the locality mentioned by Mr. Girard for the type. There is no doubt that these males are the young of the species above described, and I think also the veritable *C. acutissimus* Gir., l. c. T. 6, p. 91.

Cambarus acutus is the largest North American species. The most important characters are: the rostrum is one and a half times as long as broad, with a distinct large impression, surrounded by a little elevated part at the base; the thorax is strongly tuberculated, posteriorly dilated, without lateral spine; the areola is impressed, very little carinated in the middle; the external lobes of the two penultimate segments of the postabdomen with the external posterior angle finished in a sharp right angle; the lamina in the middle of the apex is large, the basal part longer than the apical, the terminal margin of which is not very deeply excised in the middle. The antennæ are as long as the body, or longer; their lamina much enlarged in the middle; the external maxillary legs always barbate; the epistoma is transversely elliptical, rounded in front; the anterior legs are very long; the brachium is longer than the rostrum; the hand has large and flat tubercles, which in front are a little hairy; the external margin of the hand and finger is straight; the internal margin nearly straight, strongly denticulated; the mobile finger is sinuated, a little longer than the exterior; the brachium is tuberculated above and inside near the carpus. The female has the venter between the fourth legs behind bi- or bisbituberculated, and a larger flat tubercle near the third legs.

The four species, *C. acutus*, *C. Clarkii*, *C. troglodytes*, and *C. Blandingii*

are very similar in size and forms. For *C. Blandingii* see the description of this species. Of the three other species, the thorax is more ovoid, more dilated in *C. acutus*; laterally more compressed in *C. Clarkii*; between the two in *C. troglodytes*, nearly as dilated as in the first, but a little more depressed. The areola is the broadest, but very narrow in *C. acutus*, the narrowest and the most shallow in *C. Clarkii*; in both species the areola is posteriorly much more dilated than anteriorly; in *C. troglodytes* the areola is nearly as broad posteriorly as anteriorly. The thorax is strongly tuberculated in *C. acutus* and *C. Clarkii*, granulated in *C. troglodytes*. The rostrum is most sinuated, and often clearly dentated in *C. Clarkii*; less sinuated and dentated in *C. troglodytes*. The rostrum is nearly plain in *C. troglodytes*, most excavated, with the margins more elevated, in *C. Clarkii*; *C. acutus* is intermediate. The base of the rostrum shows a different structure, but a little obscure. There is in *C. acutus* and *C. Clarkii* a circular depression, terminated in front by a somewhat rounded elevation in *C. acutus*; in *C. Clarkii* by two oblique straight elevations, united in an obtuse angle; in *C. troglodytes* there is in the circular depression a very flat, central, round elevation or tubercle. The postabdomen is the narrowest and laterally most compressed in *C. Clarkii*; the apical part of the lamina is longer in *C. troglodytes* than in the other species. The hands are the shortest and broadest in *C. troglodytes*; the fingers nearly as long as the hands, in the other species much longer, in *C. Clarkii* they are deflected. The movable annulus in the female of *C. troglodytes* is striking; it is very firmly united with the venter between the fourth legs in the two other species.

Cat. No. 1161, New Orleans, La., L. Agassiz. Mas. Form I. Fem. Specimens, 12.*

Cat. No. 1843, New Orleans, La., L. Agassiz. Mas. very large, Form I. Spec. 1.

Cat. No. 1844, New Orleans, La., L. Agassiz. Mas. Form I. and II. Fem. Spec. 12.*

Cat. No. 1845, New Orleans, La., L. Agassiz. Mas. Form II.; first pair of abdominal legs articulated or not articulated. Spec. 12.*

Cat. No. 291, Mobile, Ala., L. Agassiz. Mas. Form I. and II. Fem. Spec. 12.*

Cat. No. 1846, Mobile, Ala., L. Agassiz. Mas. Form I. and II. Fem. var. *thorace læviori*. Spec. 12.*

Cat. No. 182, Charleston, S. C., L. Agassiz. Fem. Spec. 1.

Cat. No. 274, St. Louis, Mo., Dr. Engelmann. Mas. young. Spec. 1.

Cat. No. 151, St. Louis, Mississippi bottom, Dr. Engelmann. Mas. Form I. Fem. Spec. 6.

Var. A. Cat. No. 214, Lawn Ridge, Ill., Mr. O. Ordway. Mas. Form I. and II. Fem. Spec. 12.*

* The star signifies that the Museum possesses more than 12 specimens.

Cat. No. 1460, Evanston, Ill., Prof. O. Marcy. Mas. Form I. and II. Spec. 2.

Cat. No. 1820, Basson Pudge, Ill., Mr. Bulten. Mas. Form I. Spec. 1.

Var. B. Cat. No. 191, Essex, N. J. Fem. Spec. 3.

Cat. No. 292, New York. Fem. Spec. 1.

Cat. No. 1821, Beaufort, N. C., Mr. T. Shute. Fem. Spec. 2.

Dry Spec. Mobile, Ala., L. Agassiz. Male Form I. Spec. 1.

Peoria, Ill., Mr. O. Ordway. Male var. A., Form I. Spec. 2.

2. CAMBARUS CLARKII Girard.

Cambarus Clarkii Girard, Proc. Acad. Philad., T. 6, p. 91.

Figures on Pl. I., II., III., and IV

First abdominal leg of the male :

first form, fig. 7 in front; fig. 8 outside.

second form, fig. 9 in front; fig. 10 outside.

young, type of *C. Clarkii*, fig. 99 in front; fig. 100 outside.

development of the first abdominal leg in the young male 0.3 inch long, fig. 133.

more augmented, to show the structure of the knob, fig. 134.

Antennal lamina, fig. 137, *a*; epistoma, *b*; spine of the second joint of the exterior antennæ, *c*.

Tab. IV. mas., first form, New Orleans.

MAS. Rostro triangulari, lato, dimidio longiori, ante apicem acutum brevem utrinque sinuato vel subdentato, margine vix punctato lineato; supra lævi, excavato, basi foveola antice leviter triangulari; cretis basalibus extus sulcatis, apice extus acutis, fere parallelis, postice tuberculoso convergentibus. Antennis externis corpore æqualibus, articulis duobus basalibus dente externo brevi subacuto; antennis internis articulo basali dente infero medio acuto; lamina externa rostro longiori, articulo antennarum tertio æquali, lata, apice rotundata, margine externo inflato, apice brevi-spinoso. Epistomate brevi, duplo latiori, antice truncato, bisinuato, lateribus oblique productis, subsinuatis. Pedibus maxillaribus externis intus et subtus barbatis. Thorace utrinque subcompresso, densius tuberculato, cephalothorace supra lævi, parce punctato, postice obsolete bicalloso; linea profunda, modice sulcata, lateribus fissa, spina infera, ad antennarum basin apicali, acuta; areola angustissima, medio lineari, profunda, postice dilatata, triangulari, plana. Postabdomine lato, compresso, apice subangustiori, lævi, vix punctato, utrinque obsolete rubro, segmentis penultimis angulo externo postico obtuso; lamina media parte apicali vix breviori, basi subattenuata, apice subsinuata; parte basali apice sinuata, utrinque bispinosa. Pedibus anticis elongatis, longitudine corporis. Chela longa, crassiori, squamoso-tuberculata, margine interno longo, subincurvo, fortiter dentato; digitis chelæ longitudine, planioribus, apice subdeflexis, subsinuatis, apicibus acutis, incurvis, lævibus, intus apice spongiosis, basi subdentatis, digito externo tuberculo medio et basali intus majoribus; digito mobili sublongiori, basi intus exciso. Carpo longo, lævi, intus

tuberculato, spina media majori; subtus spinis duabus majoribus anticis, aliisque minoribus internis. Brachio rostro longiori, extus lævi, intus ante apicem et margine supero tuberculato, spinis duabus anteapicalibus oblique positis; subtus biseriatim spinoso, spinis internis apicalibus validis. Pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis et quintis capitulo basali, quartis oblongo-ovali, quintis compresso, laminato.

Pedibus abdominalibus brevibus, rectis, cylindricis, basi et ante apicem attenuatis, vix bifidis; parte externa margine postico dente medio obtuso, apice dentibus brevibus duabus compressis, corneis, latis, rotundato-incurvis; parte interna apice spina fusiformi, acuta.

Forma II. differt antennis chelisque brevioribus, unguiculis pedum minoribus; pedibus abdominalibus basi articulatis, minus attenuatis, parte externa apice fere obtuso, bituberculato, dentibus obscurioribus, nec fusco-corneis; parte interna spina conica breviori.

Mares formæ secundæ variant brachio rostro breviori, lateribus cephalothoracis minus tuberculatis; spina laterali ad lineam transversam (semper fere nulla in Forma I.); forma et latitudine rostri et acuminis variabili, vel marginibus rectis, vel subrotundatis; acumine basi distinctius dentato.

Femina differt antennis chelisque brevioribus, minoribus, minus tuberculatis; ventre inter pedes quartos nudo, non tuberculato; annulo ovali, obtuse conico, fissura longitudinali, labiis antice inflatis, sulcatis, fere bituberculatis.

Long. 3 and 4 unc. Mas maximus; long. 4.2; ped. ant. 4.7; antenn. 4.5; chelæ, 2.6.

Patria: New Orleans. Between San Antonio, Texas, and El Paso del Norte. Vidi specimina multa, adulta et juniora.

This species is very similar to *C. acutus*, but it differs surely; the rostrum is more evidently dentated before the acumen, and the obsolete impression at its base is terminated anteriorly by two oblique elevated lines; the epistoma is truncated and sinuated anteriorly and laterally; the thorax is laterally compressed, the areola linear in the middle; the penultimate segments of the postabdomen with the exterior angle are more obtuse; the apical part of the intermediate lamina is as long as the basal, a little attenuated at the base; the chelæ are shorter and broader; the legs of the postabdomen different; the venter of the fourth legs in the female is without tubercles. There is rarely one spine at the sides of the thorax.

C. Clarkii Girard. I have most carefully compared male and female types collected by the U. S. Mexican Boundary Commission, communicated by Professor Stimpson. They belong, without doubt, to this species. The male is a young specimen of the Forma II. (1.8 unc.

long); the female is smaller. The first abdominal leg of the male, figured by me after the type, shows exactly the shape of the male full-grown Forma II., but not as well finished as it is always found in the young specimens. I have not seen a similar young specimen from New Orleans; the smallest is 2.6 unc. long, but agrees very well. The young of *C. troglodytes*, of which I have seen specimens 0.6 unc. long, are very similar; but *C. Clarkii* differs in having the rostrum exactly triangular and a little attenuated at the tip (it is more dilated, with the margins curved, in *C. troglodytes*); the acumen is longer, more acute (in *C. Clarkii* type $\frac{5}{50}$ unc. left side, $\frac{6}{50}$ right side); the basis of the rostrum has two obsolete elevations connected in an obtuse angle; the lamina of the antennæ is more elongated, smaller at the tip.

In the Museum of the Natural History Society of Boston are two females, together with a great number of apparently very young animals, before described by me.

Cat. No. 1162, New Orleans, La., L. Agassiz. Mas. Form I. and II. Fem. Spec. 12.*

Cat. No. 166, New Orleans, La., L. Agassiz. Mas. Form I. Fem. Spec. 5.

Cat. No. 264, New Orleans, La., Mr. Allen. Mas. Fem., young. Spec. 3.

Cat. No. 1822, Mobile, Ala., L. Agassiz. Mas. Form II., young. Spec. 2.

3. CAMBARUS TROGLODYTES *Le Conte*.

Astacus troglodytes LeC., Proc. Acad. Philad., T. 7, p. 400.

Figures on Pl. I. and III.

First abdominal legs of the male:

first form, fig. 11 in front, fig. 12 outside.

second form, fig. 13 in front, fig. 14 outside.

Antennal lamina, fig. 141, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro triangulari, lato, tertia parte longiori, subdeflexo, ante apicem acutum, brevem, paulo barbatum, utrinque leviter sinuato; supra fere plano lævi, utrinque subtiliter marginato, tuberculo obsolete plano in foveola basali orbiculari; cretis basalibus extus sulcatis, apice subacutis, subparallelis. Antennis gracilibus, corpore paulo brevioribus, articulis duobus basalibus dente externo parvo subacuto; antennis internis articulo basali dente infero medio acuto; lamina externa rostro longiori, articulo antennarum tertio vix breviori, lata, apice vix rotundata, margine externo inflato, apice brevi spinoso. Epistomate lato, antice et utrinque subsinuato (forma variabili, semper brevi, lateribus obliquis). Pedibus maxillaribus intus et basi subtus villosis. Thorace postice latiori, postice subdepresso, granuloso, cephalothorace medio fortius punctato, postice obsolete bicalloso, linea modice profunda et sinuata, lateribus fissa, spina infera ad antennarum basi apicali acuta; areola media angusta, subcarinata, postice latiori, transverse

impressa. Postabdomine subangustiori, lævi; segmentis penultimis angulo externo obtuso; lamina media parte apicali vix breviori, antice subrotundata; parte basali apice sinuata, utrinque bi-(vel tri)-spinosa. Pedibus anticis elongatis, corpore vix brevioribus; chela longa, crassiori, squamoso-tuberculata, margine interno longo, subrecto, densius tuberculato et fortiter dentato; digitis paulo longioribus, arcuatis, subcostatis, leviter punctato-lineatis, apicibus acutis, incurvis; intus apice squamosis, basi serratis; digito externo tuberculo medio et basali internis majoribus obtusis; digito mobili sublongiori, basi sinuata, tuberculo majori. Carpo longo, lævi, intus subtuberculato, spina media interna majori; subtus spinis duabus anticis majoribus. Brachio rostro longiori, extus lævi, intus ante apicem tuberculis nonnullis minoribus; margine superiori leviter tuberculoso, spinis duabus majoribus oblique positis; subtus biserialim spinoso, spinis apicalibus validis. Pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis capitulo basali, latiori; quintis lamina quadrangulari, parva elevata. Pedibus abdominalibus brevibus, rectis, parte interna intus lata, plana, spina media posteriori, apice bifida; ramo antico brevi, fusiformi, acuto; ramo postico longiori, laminato compresso; parte externa cylindrica, valde bi-attenuata, dente apicali brevi, fusco corneo, triangulari.

Forma II. differt chelis brevioribus, unguiculis pedum minoribus; pedibus abdominalibus basi articulatis, parte interna ramo interno fere obtuso; parte externa dente apicali minori nec fusco corneo; spina thoracis laterali interdum distincta.

Femina differt antennis chelisque brevioribus, minoribus; ventre inter pedes tertios tuberculato, inter pedes quartos nudo; annulo obovali, fissura longitudinali, dentibus alternis, modice inflatis; annulo mobili, nec ventre præcedenti connato.

Long. 3. Mas maximus; long. 3.8; ped. ant. 3.7; antenn. 3.5.

Patria: Charleston, South Carolina; Lawn Ridge, Illinois; Rocky River, Olmsted, Ohio; Georgia.

(Habitat in Georgiæ oryzaceis, ubi spiracula 4 unc. alta format. LeConte.)

I have seen many very young specimens 0.6 inch long.

From Georgia I have seen but four specimens, two males (Forma I.), and two females. The first abdominal legs in the male are a little different in shape. The tip is more recurved, not straight as in the others. Apparently this is the veritable *A. troglodytes* LeC., and the intermediate lamina is always trispinose.

A. troglodytes male type LeConte (Mus. Philad.), with the dimensions given by Mr. LeConte, is identical with the males from Charleston. The abdominal legs are (Forma I.) similar; the lamina is trispinose.

The specimens before mentioned, from Georgia, are not essentially different, though the thorax is more compressed. The female has the areola larger. Some females from Charleston have the lamina also trispinose. It seems not prudent to separate the two species, for the materials are insufficient.

A single male, the largest seen by me, was in the same bottle with *A. obesus*, from Lawn Ridge, Illinois.

The posterior hooks of the abdominal legs of the male exist in the young males, Forma II.; in the very young they are sometimes absent; sometimes they disappear. The fingers are not arcuated in the younger male and female specimens.

A large female (dry), in the Cambridge Museum, communicated by L. R. Gibbes, as *A. Blandingii* Harl. from South Carolina, is *A. troglodytes*.

A. fossarum LeConte. A dry specimen (Mus. Philad.), a female, agreeing very well with the description, does not differ from *A. troglodytes*. It possesses the same compressed thorax, like the specimens from Georgia.

C. Blandingii (Mus. Philad.), from Charleston, is a male, Forma II., of *C. troglodytes*, and perhaps a type of *C. Blandingii* Girard.

Cat. No. 182, Charleston, S. C., L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 283, Charleston, S. C., Mr. Crady. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 197, Lawn Ridge, Illinois, Mr. O. Ordway. Male Form I. Spec. 1.

Cat. No. 1823, Georgia. Male Form I. and II. Fem. Spec. 4.

Dry spec. South Carolina, L. R. Gibbes. Male, labelled "*A. Blandingii*." Spec. 1.

Rocky River, Olmsted, Ohio, L. Agassiz. Male. Spec. 1.

Charleston, S. C., L. Agassiz. Male. Spec. 1.

4. CAMBARUS BLANDINGII *Harlan*.

Astacus Blandingii Harl, Trans. Amer. Philos. Soc., T. 3, p. 464. Harlan. Med. and Physic. Research, p. 229, fig. 1.

Figures on Pl. I. and III.

First abdominal legs of the male :

first form, fig. 63 in front, fig. 64 outside.

Antennal lamina fig. 140, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro triangulari, lato, lævi, excavato, marginibus summa basi parallelis, lineato-punctatis; acumine brevi, angusto, acuto, utrinque subsinuato; cretis basalibus validis, extus sulcatis, apice subacutis parallelis, postice calloso-convergentibus. Antennis validis, corpore brevioribus (?secundum Harlani figura), articulis duobus basalibus dente acuto externo; antennis internis articulo basali dente medio

infero; lamina rostro paulo longiori, pedunculo antennarum æquali, ante medium latiori, apice angusta, margine externo inflato, apice brevi-spinoso. Epistomate longitudine vix latiori, antice rotundato, lateribus obliquis, angulis lateralibus rectis. Pedibus maxillaribus intus et subtus barbatis. Thorace leviter ovali, grosso-punctato, lateribus granulosis; cephalothorace medio læviori, rarius punctato, postice bicalloso; linea ordinaria profunda, sinuata, utrinque fissa, spina laterali mediocri, spinaque infera apicali; areola angusta, profunda, postice paulo latiori, punctata. Postabdomine thorace vix angustiori, lævi, segmentis penultimis angulo externo postico recto; lamina media parte apicali vix breviori, margine apicali medio vix exciso; parte basali apice utrinque bispinosa. Pedibus anticis valde elongatis, sub-cylindricis; chela longa depresso-cylindrica, dense squamoso-tuberculata, margine interno longo recto, subdentato; digitis margine interno chelæ æqualibus, intus curvatis, gracilibus, carinatis, punctato-ciliatis, intus squamosis; digito interno paulo longiori; carpo longo, angusto, antice oblique truncato, intus tuberculato, spina interna media, aliaque antica minori, spinis duabus inferis anticis; brachio rostro longiori, extus lævi, intus ante apicem et margine supero tuberculato, spinis duabus anteapicalibus oblique positis. Subtus biseriatim spinoso, spina utrinque antica ad articulationem. Pedibus tertiis et quartis articulo tertio valde unguiculato; pedibus quartis capitulo basali ovali, compresso; quintis perbrevis, acuto. Pedibus abdominalibus validis, rectis; parte interna brevior, recta (dente apicali fracto); parte externa latiori, subcontorta, apice non angustiori; dentibus tribus fusco-corneis, medio longiori, antico lato, contorto, postico parvo, angusto, fere recto.

Long. corp. 3.8 inch; ped. ant. 3.9.

Patria: Camden, South Carolina (mas. Form I.)

I have only seen the type described and figured by Mr. Harlan, preserved dry in the Museum of the Philadelphia Academy, and labelled, "*A. Blandingii* Harlan, Camden, S. C., Dr. Blanding." Camden is situated in the mountains, but Mr. Harlan (in the Trans. Amer. Philos. Soc. l. c.) says: "All the crawfish which I have seen from the Southern States, and I have received specimens from New Orleans and South Carolina, are the same species with that now described." I have most carefully examined several hundred specimens from New Orleans and South Carolina, (the collection in the Museum of Cambridge being very rich for these localities,) but I have not found a single specimen of *C. Blandingii*. The description and the figure given by Mr. Harlan agree very well with his type; but the hand is no broader at the base than seen in the right hand of the figure. The hand is two inches long; the inner finger seems when open 0.1 inch longer than the external, it is as long as the hand, 1 inch.

Cambarus Clarkii and *C. troglodytes* are very similar, but instantly sepa-

rated since the epistoma is truncated at the tip. *C. Clarkii* differs in having the thorax strongly tuberculated, the areola linear or none; the base of the rostrum with two linear elevations joined in obtuse angle; the second article of the exterior antennæ, with the teeth shorter than its tubercle (as long as in *C. Blandingii* and very acute); the lamina is more enlarged at the tip; the hands broader, shorter, the fingers more arcuated and deflected, more tuberculated (one tubercle on the inside of the external finger in the middle in *C. Blandingii*); the abdominal legs differ also. *C. troglodytes* differs by the same characters.

C. acutus Gir. is very near in the shape and sculpture of the rostrum and epistoma, but the lamina is much larger at the tip; the teeth of the second article are shorter than the tubercle, the hands broader and shorter, the abdominal legs different. I have seen some hundred males of all sizes, but never a male with the abdominal legs analogous to *C. Blandingii*. The body is more tuberculated.

The females from Essex, New Jersey, quoted under *C. acutus* (but it is always difficult to identify females with males) are more similar, the body is not very strongly tuberculated, the lateral spine is evident, the lamina smaller at the tip.

C. LeContei is very near, but the abdominal legs are different; the shape of the hand is most similar, but the fingers are shorter and straight; the rostrum strongly dentated at the tip, the areola broad. The typical specimen of *C. Blandingii* is very well developed and it does not seem to me to be an abnormal specimen of *C. acutus* with abnormal hands, abdominal legs, and lamina. I cannot help regarding it a good species, perhaps (?) identical with the New Jersey females described provisionally as *C. acutus*.

It is not impossible that *C. Blandingii* LeConte, l. c. p. 400 (Georgiæ et Carolinæ regionibus intermediis), is this species, but in this the linea ordinaria is sulcated as in *C. troglodytes*, and not sulcated in *LeConte's* species. Erichson gives but a copy from Mr. Harlan's description.

C. Blandingii Gir., l. c. p. 91, without description, is probably *C. troglodytes*, which the Museum possesses from the same locality, Summerville, South Carolina, given by Mr. Girard. (Vide *C. LeContei*.)

5. CAMBARUS FALLAX *Hagen*.

Figures on Pl. I.

First abdominal leg of the male :

first form, fig. 103 in front, fig. 104 outside.

second form, fig. 105 inside.

MAS. Rostro elongato triangulari, lævi, excavato; acumine subacuto, ciliato, spina utrinque acuta; cretis basalibus validis, parallelis, extus vix sulcatis, apice acutis. Antennis gracilibus, corpore brevioribus, articulis duobus basalibus dente acuto externo; antennis internis

articulo basali dente medio infero; lamina rostro pedunculoque antenarum longiori, ante medium latiori, margine externo latius inflato, spina apicali acuta longiori. Epistomate lato, rotundato, antice medio subacuto; pedibus maxillaribus externis intus barbatis. Thorace angusto, compresso, punctato, lateribus scabris; linea profunda, sinuata, lateribus fissa; spina brevi valida, postice leviter barbata, aliaque infera acuta ad antennarum basin; areola plana, punctata, angusta, postice latiori. Postabdomine lato, compresso, thorace longiori, parcepunctato, segmentis penultimis angulo externo subrecto; lamina media parte basali quadrangulari, apice utrinque trispinosa; parte apicali æquali, apice angulis rotundatis. Pedibus anticis longis, gracilibus, angustis; chela elongata, angusta, depresso-cylindrica, leviter squamoso-tuberculata; margine interno longo, recto, subdentato; digitis paulo brevioribus, rectis, subcostatis, intus squamosis; digito mobili margine externo subdentato. Carpo longo, angusto, parce tuberculato, spina antica et media interna breviori; subtus spina antica externa; brachio longiori, sublævi, spinis duabus anteapicalibus oblique positis; subtus biseriatim spinoso, utrinque ad articulationem spina antica acuta. Pedibus secundis chela parce villosa; pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis et quintis capitulo basali, quartis oblongo majori, quintis compresso, triangulari, erecto. Pedibus abdominalibus validis, brevibus, rectis; parte externa spina anteapicali acuta, obliqua; parte externa dentibus perparvis fusco corneis adpressis.

Forma II., differt pedibus tertiis et quartis unguiculo minori; chela læviori; pedibus abdominalibus basi articulatis, parte interna spina anteapicali fortiori; parte externa apice rotundato; intus ad apicem fortiter sulcatis.

Femina junior differt chela brevi, minori; ventre inter pedes quartos lævi; annulo transversali, valido, fissura longitudinali antica recta, postica dentato-tuberculata.

Long. corp. 2.9; antenn. 2.4; ped. antic. 1.9.

Patria: Florida. Museum Boston Natural History Society.

I have seen only one male of each form (the male of the second form is even a little larger), and two very young females. This species is very near *C. LeContei*, but differs in the longer thorax, the hands, and the abdominal legs. The legs, especially in the second form, are strongly sulcated on the inner side.

6. CAMBARUS LECONTEI *Hagen.*

Figures on Pl. I. and III.

First abdominal leg of the male:

first form, fig. 15 in front; fig. 16 outside.

second form, fig. 17 in front; fig. 18 outside.

Antennal lamina, fig. 145, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro triangulari, lato, lævi, excavato, marginibus basi fere parallelis, lineato-ciliatis; acumine acuto, ciliato, utrinque spina acuta; cretis basalibus validis, parallelis, extus sulcatis, apice acutis. Antennis corporis fere longitudine, articulis duobus basalibus dente acuto externo; antennis internis articulo basali dente media infera; lamina rostro pedunculoque antennarum sublongiori, ante medium latiori, margine externo latius inflato, spina apicali breviori. Epistomate lato, antice rotundato, angulis externis fere rectis; pedibus maxillaribus externis intus barbatis. Thorace subcompresso, punctato-pubescente, lateribus scabris; linea profunda, vix sinuata, lateribus fissa, spina brevi valida, aliaque apicali infera acuta ad antennarum basin; areola angusta, plana, punctata, postice subito latiori, ante marginem thoracis posticum excisum transverso-impressa. Postabdomine lato, thorace longiori, parcepunctato, segmentis penultimis angulo externo rotundato; lamina media parte basali quadrangulari, apice utrinque tri-(vel quadri-) spinosa; parte apicali breviori, apice leviter emarginato. Pedibus anticis longis, gracilibus, angustis; chela longa, angusta, depressocylindrica, ubique squamoso-tuberculata, ciliata; margine interno longo, recto, subdentato; digitis paulo brevioribus, rectis, subcostatis, dense ciliatis, intus squamosis; digito externo dente medio interno minori. Carpo longo, angusto, leviter squamoso-tuberculato, spina antica interna et media majoribus; intus spinoso, spinis duabus anticis validis; brachio longiore, extus sublævi, margine supero et intus ad apicem tuberculato, spinis duabus oblique positis anteapicalibus; subtus spinis nonnullis biseriatis; utrinque ad articulationem spina antica acuta. Pedibus secundis chela intus villosa; pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis et quintis capitulo basali, quartis oblongo, majori, quintis triangulari, compresso, erecto. Pedibus abdominalibus validis, brevibus, rectis, parte interna apice dente fusco corneo incurvo, spinaque anteapicali longiori transversali; parte externa, æquali, subcontorta medio crassiori, apice dentibus tribus incurvis acutis.

Forma II. differt pedibus tertiis et quartis unguiculo minori, chela angustiori, breviori fere lævi; pedibus abdominalibus basi articulatis, dentibus apicalibus non fusco corneis, condunatis, latioribus.

Femina differt chela breviori, obsolete tuberculosa; ventre inter pedes quartos apice bituberculato; annulo transversali, valido, fissura longitudinali, labiis alternatim crassioribus.

Long. corp. 3.8; antenn. 3.5; ped. antic. 3.2.

Patria: Mobile, Alabama; Pensacola, Florida; Beaufort, North Carolina; Milledgeville, Georgia; Root Pond, Mississippi; vidi 30 specimina.

I had previously considered this species as *C. angustatus* LeConte; but the type in the Philadelphia Museum is surely different (viz. *C. spiculifer*). This species is separated from the similar ones by the short mesothorax, the longer abdomen, and the long, small, and nearly cylindrical hands.

I consider *A. Blandingii* LeConte, l. c. T. 7, p. 400, as probably identical with *C. Lecontei*. The words "linea ordinaria non sulcata" do not agree very well; the transverse line is as sulcated as in *C. troglodytes*. The lamina of the postabdomen is bispinose in Mr. LeConte's species, trispinose in *C. Lecontei*. Still it seems probable that the two species are as likely to be identical with each other as with *C. Blandingii* Harlan.

Cat. No. 201 and 217, Mobile, Ala., L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 1824, Beaufort, N. C., Mr. T. Shute. Fem. Spec. 1.

Cat. No. 246, Milledgeville, Ga. Fem., and young. Spéc. 4.

Cat. No. 307, Root Pond, Miss., Mr. Wailes. Male Form II. Spec. 1.

Cat. No. 249, Pensacola, Fla. Male, Fem., young. Spec. 3.

7. CAMBARUS SPICULIFER *Le Conte*.

Astacus spiculifer LeConte, Proc. Acad. Philad., T. 7, p. 401.

Figures on Pl. I. and III.

First abdominal legs of the male:

first form, fig. 59 in front; fig. 60 outside.

second form, fig. 61 in front; fig. 52 outside.

Antennal lamina, fig. 147, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro longo, lævi, excavato, basi obsolete impresso, marginibus punctato-ciliatis, basi parallelis, deinde subconvergentibus; acumine longo, angusto, triangulari, acuto, utrinque spina breviori acuta; cretis validis, modice elevatis, parallelis, extus obsolete sulcatis, apice breviter acutis, postice obsolete inflatis, convergentibus. Antennis validis, corpore paululum brevioribus, articulis duobus basalibus dente externo acuto; antennis internis articulo basali dente medio infero acuto; lamina rostro fere longiori, medio latiori, apice angusta, margine externo latius inflato, spina modica acuta apicali. Epistomate lato, antice triangulari, angulis lateralibus rotundatis; pedibus maxillaribus externis intus barbatis. Thorace leviter ovato, punctato, lateribus leviter granulatis, vel partim tuberculosus; cephalothorace postice obsolete bicalloso; linea profunda, lateribus fissa, utrinque spinis duabus validis acutis; spina antica infera breviori ad antennarum basin; areola lata,

ad marginem anticum utrinque impressa, postice latiori, calloso-inflata; margine thoracis postico sinuato. Postabdomine thorace longiori, lato, subcompresso, parce-punctato, segmentis antepenultimis angulis lateralibus fere rectis; lamina media parte basali apice utrinque bispinosa (interdum trispinosa), parte apicali breviori, angulis rotundatis. Pedibus anticis longis, validis; chela longa, lata, subdepressa, ubique tuberculis majoribus obtusis, subtus rarioribus, margine interno subrecto, fortiter dentato; digitis vix brevioribus, planis, subcostatis, punctato-ciliatis; digito interno recto, sublongiore, utrinque dentato; externo incurvo, intus dentato, dente anteapicali majori. Carpo longo tuberculato, extus nudo, spina media interna valida; subtus spinis duabus apicalibus validis, intus bi-vel triseriatim spinoso; brachio longo, margine supero tuberculato, spinis duabus anteapicalibus acutis, subtus spinis biseriatis, anticis utrinque ad articulationem validis. Pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis et quintis capitulo basali, quartis ovato majori, quintis minori, laminato, erecto. Pedibus abdominalibus validis, apice paululum divisis, parte externa ante apicem angustiori, apice extus barbata, dentibus duobus fusco-corneis incurvis, supero longiori; parte interna fusiformi, apice spina longiori, gracili, subrecta, partem externam non superante.

Forma II. differt chelis minoribus, minus tuberculatis; unguiculis articuli tertii minoribus; pedibus abdominalibus basi articulatis, parte interna fortiori, spina apicali mobili, extus curvata; parte externa apice dentibus conicis, nec fusco-corneis, subincurvis; capitulo basali pedum posticorum minus expresso.

Femina differt antennis brevioribus, chela minori; ventre inter pedes quartos lævi, postice utrinque tuberculo compresso; annulo transverso, sulco antico longitudinali, lumine transverso, profundo, postico.

(Maxim.) Long. corp. 3.6; antenn. 3.3; ped. antic. 3.2.

Habitat: Athens, Georgia; Roswell, Georgia. Vidi multa specimina.

The females from Roswell differ a little in having the venter between the fourth legs not so much tuberculated, and the annulus less open. The males (Forma II.) seem to be identical.

I have seen the male type, Forma II., in the Mus. Philadelphia.

Cat. No. 172, Athens, Ga., Dr. J. LeConte. Male Form I., Fem. Spec. 12.*

Cat. No. 222, Roswell, Ga., Mr. N. A. Pratt. Male Form I., Fem. Spec. 5.

8. CAMBARUS ANGUSTATUS *Le Conte*.*Astacus angustatus* LeConte, Proc. Acad. Philad., T. 7, p. 401.

Figures on Pl. I. and III.

First abdominal legs of the male.

First form, fig. 65 in front, fig. 66 outside, fig. 67 inside.

Antennal lamina, fig. 146, *a*; epistoma, *b*; spine of the second joint of the exterior antennæ, *c*.

A little dry typical specimen, communicated to the Museum of the Philadelphia Academy by Mr. LeConte, is very difficult to identify with any specimen before me. It is a male (Forma I.), 1.95 inch long, hands 1.2 long, and agrees with the description. It seems to be a young male of *C. spiculifer* or a new species. The differences quoted in the descriptions of *C. spiculifer* and *C. angustatus* are not decisive. The rostrum in *C. angustatus* is described: "valde acuminatum, utrinque versus apicem fortiter et acute unidentatum"; in *C. spiculifer*: "longissime acuminatum, denticulo parvo utrinque ad acuminis basin." The two types show no difference, except that in *C. angustatus* the rostrum is not so narrow before the acumen. I have seen similar differences in *C. spiculifer*. *C. angustatus* is "linea ordinaria apice spina armata," but the same spine exists in *C. spiculifer*. The thorax has but one lateral spine (not at all noticed in the description), and two in *C. spiculifer*. But I have seen *C. spiculifer* with two, with three, and even with one spine. The lamina intermedia of the postabdomen has sometimes three apical spines in *C. spiculifer* as well as in *C. angustatus*. I should not hesitate to unite the two species (*C. spiculifer* as Forma II., and *C. angustatus* as Forma I. of the male), did I not find two differences not so easy to explain.

1. The hands are longer and narrower, not so tuberculated in *C. angustatus*; the fingers a little shorter than the hands, and inside always spongiose. I have seen hands nearly of the same shape in young *C. spiculifer*, but the fingers were always as long as the hands or longer, and not always spongiose, although sometimes a little so at the tip.

2. The first pair of abdominal legs are a little more obtuse at the tip, with the posterior border a little more dilated, and are sulcated on the inside. I confess that these differences are perhaps rather too minute, but the two together seem more important. I should expressly remark, that the type of *C. angustatus* seems well developed, and the hooks in the third and fourth legs strong. Finally, as Mr. John LeConte has seen and observed the species alive, and I have only two single specimens, I prefer to separate *C. angustatus*; a further examination may perhaps bring out more strongly the differences of the two nearly allied species.

"*C. angustatus* is found in Georgia inferiore, in aquæ puræ rivulos inter colliculos arenosos, *C. spiculifer* in Georgia superiore."

9. CAMBARUS VERSUTUS *Hagen.*

Figures on Pl. I. and III.

First abominal leg of the male :

first form, fig. 55 in front ; fig. 56 outside.

second form, fig. 57 in front ; fig. 58 outside.

Antennal lamina, fig. 150, *a* ; epistoma, *b* ; spine of the second joint of the exterior antennæ, *c*.

MAS. Rostro longo, lævi, excavato ; marginibus nudis, basi fere parallelis, deinde subconvergentibus ; acumine angusto triangulari, acuto, utrinque spina valida subrejeta ; cretis basalibus validis, fere parallelis, extus sulcatis, apice spina acuta longiori. Antennis corporis fere longitudine, articulis duobus basalibus dente externo acuto longiori ; antennis internis articulo basali dente medio infero longiori, acuto ; lamina rostro pedunculoque antennarum longiori, media latiori, margine externo lato inflato, spina apicali longiori. Epistomate brevi, lato, antice obtuso triangulari, angulis lateralibus rotundatis ; pedibus maxillaribus externis intus barbatis. Thorace fere cylindrico, lævi, utrinque antice subscabro ; linea profunda, lateribus breviter fissa, spinis utrinque duabus validis, acutis ; areola lata plana, antice posticeque latiori ; margine thoracis postico exciso. Postabdomine thorace vix angustiori, paulo longiori, lævi, segmentis antepenultimis angulo externo subrecto ; lamina media parte basali elongato-quadrangulari, apice utrinque tri-(interdum bi-vel quadri)-spinosa ; parte apicali breviori, antice rotundata. Pedibus anticis modicis, gracilibus ; chela angusta, media inflata, densius tuberculato-squamosa ; margine interno subrecto, dentato ; chela subtus læviori, ad marginem internum distincte sulcata ; digitis chelæ longitudine, angustis, subcarinatis, subsinuatis, intus vix leviter serratis. Carpo longo, lævi, intus tuberculato, apice oblique truncato, spina antica et media internis acutis, longioribus ; subtus spinis duabus anticis majoribus ; brachio breviori, lævi, spinis duabus anteapicalibus oblique positis ; subtus spinis validis biseriatis, utrinque ad articulationem spina antica acuta ; pedibus tertiis et quartis articulo tertio unguiculato ; pedibus quartis capitulo basali ovato, quintis minori laminato, erecto. Pedibus abdominalibus brevibus, modicis, partim intus ciliatis ; parte interna cylindrica, spina anteapicali acuta ; parte externa ante apicem angustiori, apice obtusiori, dentibus tribus internis fusco-corneis, incurvis.

Forma II., differt chelis angustioribus, depresso-cylindricis, rostro interdum magis triangulari ; pedibus abdominalibus basi articulatis, apice obtusioribus, parte interna ante apicem angustiori, spina anteapicali transversali ; parte externa apice obtuso, dentibus obsoletis, nec fusco-corneis ; pedibus tertiis unguiculo minori.

Vidi marem majorem (Forma II.) pedibus abdominalibus basi non articulatis.

Femina differt chelis minoribus; ventre inter pedes quartos apice exciso, tuberculis conicis duobus apice approxinatis; annulo transversali angusto, longitudinaliter fisso.

Maximus. Long corp. 2.6 – 3; antenn. 2.5 ; ped. antic. 2 – 2.5.

Patria: Spring Hill, Alabama; ten miles west of Mobile. — Vidi specimina multa.

Sometimes in the larger examples the thorax is more punctulated, and more granulated on the sides.

This species is very similar to *C. Lecontei*, but it differs in having a smaller and more parallel rostrum, a shorter mesothorax, twice as broad as an areola, two spines on each side, somewhat shorter but broader hands, its inner margin slightly curved, sulcated beneath, the fingers a little curved, and the sexual parts.

C. versutus, *spiculifer*, *Lecontei*, and *angustatus* (if it be not identical with *C. spiculifer*) form a single group. The mesothorax is short; the abdomen a little longer than the thorax; the areola is broader; the lamina is longer than the pedunculus, and the rostrum long and slender; the spines of the antennal joints are well developed. Besides the differences taken from the sexual organs, *C. Lecontei* and *angustatus* have one lateral thoracic spine, while *C. spiculifer* and *versutus* have two lateral thoracic spines. *C. Lecontei* is separated by long and nearly cylindrical hands; *C. spiculifer*, by strongly tuberculated hands.

Cat. No. 190, Spring Hill, Ala., L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 1825, ten miles east from Mobile, Ala., L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

10. CAMBARUS MANICULATUS *Le Conte*.

Astacus maniculatus LeConte, Proc. Acad. Philad., T. 7, p. 401.

I have not seen this species, which is described by Mr. LeConte as follows: —

Rostrum subplanum, vix concavum, obtusum cum acumine, versus apicem utrinque unidenticulatum. Lamina antennalis pedunculum æquans. Cephalothorax supra punctatus, lateribus sparsim granulosus. Areola suturalis angustissima, stria solum. Dorsum sicut in prioribus. Chela parva, angusta, tuberculato-punctata, margine interiore dentata, digiti recti, carinati, punctati. Carpus intus paucidentatus, dentibus tribus superioribus majoribus spiculæformibus. Brachium punctatum, latere superiore vix serrato, duabus tamen spinis brevibus anterioribus,

inferiore seriebus duabus spinularum. Lamellæ caudalis intermedia pars anterior trispinosa.

Long. corp. 2.3 inch ; antenn. 1.3 ; chelæ, 0.5.

Patria : Habitat cum priore (*C. fossarum*) in fossis Georgiæ inferioris.

The number of the hooked legs is not mentioned, and perhaps this species belongs to the group of *C. affinis*. The "areola suturalis angustissima, stria solum," is a very striking character, suggesting more or less agreement with *C. Clarkii*, *C. Wiegmanni*, *C. lancifer*, *C. obesus*, *C. advena*, and *C. Carolinus*. *C. advena* is otherwise described by LeConte ; in *C. Carolinus*, *C. obesus*, and *C. Clarkii* the hands are different ; in *C. lancifer* and *C. Wiegmanni* the rostrum differs.

11. CAMBARUS PENICILLATUS *Le Conte*.

Astacus penicillatus LeConte, Proc. Acad. Philad., T. 7, p. 401.

Figures on Pl. I. and III.

First abdominal legs of the male :

first form, fig. 93 in front ; fig. 94 outside.

second form, fig. 95 in front ; 96 outside.

Antennal lamina, fig. 149, *a* ; epistome, *b* ; spine of the second joint of the exterior antennæ, *c*.

MAS. Rostro lato, longo, plano, lævi, apice subdeflexo, marginibus ad acuminis brevis acuti apicem elevatis, convergentibus, antice subito incurvis ; cretis vix elevatis, subparallelis, lineato-impressis, muticis. Antennis modicis corpore brevioribus ; articulis basalibus duobus dente parvo externo ; antennis internis articulo basali dente infero submarginali ; lamina brevi, lata, apice fere truncata, margine externo inflato, spina apicali acuta. Epistomate brevi, lato, antice obtuse-triangulari ; pedibus maxillaribus externis intus et subtus barbatis. Thorace cylindrico, compresso, punctato, lateribus granuloso ; linea modice profunda, subsinuata, lateribus divisa, apice mutica ; areola punctata, modica, postice valde dilatata. Postabdomine thoracis longitudine ac latitudine, lateraliter compresso ; lamina media parte basali apice utrinque bispina, parte apicali elliptica, vix breviori ; segmentis anteapicalibus angulis externis posticis obtusis, rotundatis. Pedibus anticis modicis ; chela, latiuscula, punctato-granulosa, margine interno recto, serrato, longe barbato ; digitis chelæ æqualibus, rectis, costatis, punctato-ciliatis, intus spongiosis, digito mobili basi extus serrato. Carpo parcepunctato, longiore, extus oblique truncato, margine interno serrato, spina media majori ; subtus læviori, spina antica media. Brachio lævi, spinis anteapicalibus parvis ; subtus biseriatim spinoso. Pedibus tertiis et quartis articulo tertio unguiculato ; pedibus quartis capitulo basali conico, quintis spina basali obtusa. Pedibus abdominalibus rectis, brevibus, apice contortis, subtus medio excisis, apice fere coadunatis ; parte in-

terna dente apicali acuto erecto ; parte externa apice incurva, internam tegente, dentibus duabus apicalibus corneis perparvis, coadunatis.

Forma II. differt chela non barbata ; pedibus abdominalibus magis cylindricis, basi articulatis, parte interna dente apicali extrorsum recurvo, parte externa dentibus non fusco corneis, majoribus, distantibus.

Femina differt chelis minoribus ; ventre inter pedes quartos lævi, annulo majori, ovali, sulco longitudinali, alternatim fisso.

Long. 1.8 ; antenn. 1.3 ; ped. ant. 1.2.

Habitat : Georgia ; Charleston, South Carolina.

Animal paulo villosum. Vidi juniores rostro acutiori, ante apicem utrinque dente acuto, pedibus maris abdominalibus dentibus magis expressis.

The description of *C. penicillatus* LeConte differs somewhat. The words, "Thorax lateribus granulatis," "brachio punctato, spinoso, tuberculato," do not answer very well to the single male, Forma I., which I have seen. But I think the species the same. The tuft of hairs along the inner margin of the hand is very striking.

Cat. No. 250, Charleston, S. C., L. Agassiz. Male, female, young. Spec. 8.

Cat. No. 254, Charleston, S. C., Professor Baird. Male Form I. Fem. Spec. 2.

Cat. No. 279, Georgia, Dr. Jones. Male, young. Spec. 1.

12. CAMBARUS WIEGMANNI *Erichson*.

Astacus Wiegmanni Erichson, Wieg. Arch., T. 12, p. 99, n. 19.

Figures on Pl. III.

Antennal lamina, fig. 151, *a* ; epistoma, *b* ; spine of the second joint of the exterior antenna, *c*.

FEM. Rostro lato, modice longo, articulum antennarum secundum vix superanti, plano, punctato, antice sensim angustiori, acumine subito ac breviter triangulari, latitudine fere dimidio breviori ; marginibus usque ad apicem elevatis ; cretis modice elevatis, postice divergentibus, extus obsolete lineato-impressis, antice muticis. Antennis validioribus, corpore brevioribus ; articulis basalibus dente parvo externo ; antennis internis dente infero medio acuto ; lamina brevi, antice latissima, margine externo inflato, spina apicali brevi, acuta. Epistomate brevi, lato, antice triangulari, acutiori ; pedibus maxillaribus intus dense, subtus minus barbatis. Thorace elongato ovato, ubique punctato, lateribus mesothoracis granulosis ; linea modica profunda, subsinuata, lateribus divisa, apice mutica ; areola punctata, angusta, postice subito latiori. Postabdomine thoracis longitudine, basi thorace latiori, subcompresso, lævi, postice angustiori ; segmentis anteapicalibus angulis externis obtusis, subrotundatis ; lamina media parte basali apice utrinque bispina

parte apicali antice rotundata (? margo deest). Pedibus anticis modicis, dense squamoso-tuberculatis; chela latiuscula, modice inflata, ubique squamoso-tuberculata, margine interno recto serrato; digitis validis, rectis, costatis et punctato-lineatis, extus squamoso-tuberculatis, intus dentatis, tuberculis basalibus validioribus. Carpo squamoso-tuberculato, margine interno dentato; subtus spinis duabus anticis. Brachio lævi, supra et antice tuberculato, subtus biseriatim dentato. Ventre inter pedes quartos nudo, annulo majori, obovato, indiviso, antice subexciso, medio transverso-elevato, postice depresso.

Long. 2.6; antenn. ; ped. ant. 1.7.

Hab.: Mexico. Acad. N. Sc. Philadelphia.

I have seen only one female, which was found by Mr. Pease. Professor Erichson has described a little smaller male (two inches long); the description agrees very well. Erichson remarks that the third pair of legs and the fourth possess a hook.

This species is apparently of the same group as *C. penicillatus*. It differs in the strongly tuberculated hands, the much enlarged lamina of the antennæ, and the small areola. This species and *A. pellucidus* have the lamina of the antennæ most dilated near the tip, all other species of this group have the greatest dilatation behind the middle and nearer the base.

Cambarus Aztecus Saussure, Revue et Magas., T. 9, p. 503, and Mém. Soc. Phys. Genève, T. 14, P. II. p. 460, fig. 23, from Tomatlan (ruisseaux dans les Terres-Chandes), seems to be identical with *C. Wiegmanni*, at least with the female described by me.

13. CAMBARUS PELLUCIDUS *Tellkampff*.

Astacus pellucidus Tellkampff, Mueller Archiv. 1844, p. 383. — Erichson, Wiegman. Archiv., T. 12, p. 95, n. 14.

Figures on Pl. I, III., and VI.

First abdominal legs of the male:

first form, fig. 68 in front, fig. 69 outside.

second form, fig. 70 in front, fig. 71 outside.

Antennal lamina, fig. 148, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro lato, longo, lævi, subexcavato, foveola basali, latiori, marginibus modice elevatis, subconvergentibus, utrinque valde excisis, spina valida, acuta, subresecta; acumine longo, angusto, acuto; cretis perparvis, fere parallelis, extus impressis, antice spina valida acuta. Antennis corpore longioribus, articulis duobus basalibus dente externo valido; articulo basali internarum dente infero subapicali acuto; lamina rostro fere longitudine, sat lata, ante apicem latiori; margine externo paulo rotundato, inflato, spina apicali acuta. Epistomate brevi, lato, subexcavato basi vix angustiori obtuse triangulari, dente medio antico interdum producto. Pedibus maxillaribus externis intus barbatis.

Thorace fere cylindrico; mesothorace longiori, postice paulo angustiori; parce punctato, lævi, lateribus subgranulosis; cephalothorace utrinque spinis nonnullis acutis; linea profunda, non sinuata, serie postica spinarum acutarum, spinaque acuta antica infera ad antennarum basin; areola sat lata, plana, lævi. Postabdomine latitudine thoracis, compresso, lævi, apice non angustiori, angulis segmentorum externis rectis; lamina media parte apicali longa elliptica, parte basali apice utrinque bispinosa. Pedibus anticis longis gracilibus, chela longa, angusta, depresso-cylindrica, subpunctata, margine interno longo, recto, dentato; margine externo subdentato; digitis vix longioribus, rectis, gracilibus, subcostatis, basi subdentatis. Carpo longo, subcylindrico, intus tuberculato, spina media acuta; subtus spinis duabus anticis acutis, serie interna tuberculosa. Brachio longo, margine supero tuberculoso, spinis duabus anteapicalibus, oblique positis; subtus spinis acutis biseriatis. Pedibus tertiis et quartis articulo tertio unguiculato; pedibus quartis capitulo basali compresso, dilatato. Pedibus abdominalibus modicis, rectis, apice contortis; parte interna fortiori, cylindrica, apice membranacea, triangulari, acuta, subincurva; parte externa vix breviori, apice cornea, subrecurva, triangulari. Oculis occultis, cornea parva, indivisa.

Forma II. Pedibus abdominalibus basi articulatis, similibus, apice obtusis, nec corneis.

Femina differt chelis minoribus; ventre inter pedes quartos nudo, annulo rotundato, clauso, medio carinato.

Long. corp. 2.6 and 3.2; antenn. 3.2 and 3.4; ped. ant. 2.1.

Hab.: Mammoth Cave, Kentucky.

I have seen thirty-eight specimens, old and young.

The Museum possesses a full-grown female of *C. Bartonii*, with the eyes well developed, found in the Mammoth Cave.

I have given the peculiarities of this abnormal species in the introduction to this genus. I remark that in the second-form males the abdominal legs are often not articulated, and that the hooks on the third and the fourth set of legs are less developed. I have seen a few specimens with the hooks on the fourth pair of legs much less developed; in one specimen, even, they are entirely wanting. This observation justifies me, perhaps, in placing *C. pellucidus* as the last species of this group, and as somewhat allied to the following group of *C. affinis*.

Cat. No. 193, Mammoth Cave, Kentucky. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 225, Mammoth Cave, Kentucky, Professor Baird. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 1826, Mammoth Cave, Kentucky. Male. Fem. Spec. 5.

Cat. No. 1827, Mammoth Cave, Kentucky. Male, very large. Spec. 1.

Dry Spec. Mammoth Cave, Kentucky. Male. Fem. Spec. 2.

II. GROUP. (TYPE, *C. AFFINIS*.)

The third legs of the males hooked; rostrum subquadrangularly elongated, with an antepical tooth on each side, at least in the young; first pair of abdominal legs bifid, elongated, straight and acute at the tip.

This group seems very natural, if we except two abnormal species, *C. immunis* and *C. extraneus*. *C. lancifer* is to be considered in some degree as an exaggerated form of this group.

Well-developed hooks always appear on the third pair of legs of the male; on the fourth pair they are never to be found; in very rare instances the second pair shows similar incipient hooks more largely developed (as in *C. virilis*).

The rostrum is exceedingly long, more than three times longer than broad, in *C. lancifer*. In all the other species the rostrum is twice, or less than twice as long as broad, of a more subquadrangular form; excavated, the margins thickened and parallel (*C. affinis*), or concave on the sides (*C. juvenilis* and *C. placidus*), or flattened, more or less straight on the sides, in the other species. The apical tooth and the two lateral teeth are all well developed, at least in the young. In *C. immunis* alone the shape of the rostrum is very different in the full-grown species. The rostrum is conical, short, and toothless, as in the third group (*C. Bartonii*); nevertheless, according to the form of the abdominal legs, it belongs to the group of *C. affinis*.

The foreborder of the cephalothorax is strongly angulated behind the antennæ in *C. lancifer*, *C. extraneus*, *C. immunis*, and *C. affinis*, straight or slightly notched in all the other species. This character serves to separate the species otherwise related to *C. affinis* into two sections of equal value.

The first pair of abdominal legs is always strongly bifid, the tips much elongated and acute. In *C. lancifer*, while the tips are not so much elongated, they are somewhat flattened, but apparently of the shape characteristic of this group. A remarkable exception is to be found in *C. extraneus*, which has the first pair of abdominal legs of the shape peculiar to the third group (*C. Bartonii*); but the rostrum and other characters prevent me from placing them otherwise than in the group of *C. affinis*.

The body and the hands in the species of the second group are shorter and broader, except in *C. lancifer*, which more nearly resembles the species of the first group. The flagellum of the inner antennæ has the internal branch visibly narrower, and sometimes even a little shorter, than the external branch. The lamina of the antennæ is smaller, shorter, and dilated in the middle, except in *C. lancifer*, the lamina of which has exactly the form described in the first group. The epistoma

is mostly truncated before in front. The basal joint of the inner antennæ has a spine beneath, in the middle, or nearer the tip.

As yet burrowing habits have not been observed in the species belonging to this group. But perhaps *C. obscurus* is identical with *Astacus fossor* Rafinesque, which burrows in meadows and milldams.

The species contained in this group are divided into four sections, or perhaps they more fitly form one natural group and three abnormal or exaggerated species, which may be described in the following terms:—

1. The rostrum is very long and acute; the lamina of the antennæ elongated, dilated near the base; the hands are narrow and elongated; the first abdominal legs somewhat flattened at the tip. (*C. lancifer*.)

2. The rostrum is more subquadrangular; the lamina of the antennæ small, short, dilated in the middle; the hands are shorter and broader; the first abdominal legs acute at the tip. (*C. affinis* and allied species.)

3. The rostrum is short, conical, toothless; the other characters are as in the foregoing groups. (*C. immunitis*.)

4. Characters as in the groups of *C. affinis*, but the first abdominal legs recurved at their extremity, the tip of which is rounded (as in *C. Bartonii*).

SYNOPSIS OF THE SPECIES.

1st SECTION.

1. *C. lancifer*.

2d SECTION.

2. *A.* The margins of the excavated rostrum thickened.

a. The margins straight, front border of the cephalothorax angulated: *C. affinis*.

b. The margins concave, front border of the cephalothorax not angulated: *C. juvenilis* and *C. placidus*.

B. The margins of the flattened rostrum not thickened, front border of the cephalothorax not angulated.

a. The rostrum carinated at the tip: *C. propinquus*.

b. The rostrum not carinated: *C. virilis*, *C. rusticus*, *C. obscurus*.

3d SECTION.

3. *C. immunitis*.

4th SECTION.

4. *C. extraneus*.

I have already mentioned that the species more closely related to *C. affinis* are separated into two sections, one with the front border of the cephalothorax angulated, — *C. affinis*, *C. lancifer*, *C. immunitis*, *C. extraneus*; the second with the front border straight or slightly notched, — *C. juvenilis*, *C. placidus*, *C. propinquus*, *C. virilis*, *C. rusticus*, *C. obscurus*. The latter section is very natural, and perhaps it would be preferable to follow this arrangement in the separation of the species described.

14. CAMBARUS LANCIFER *Hagen.*

Figures on Pl. I. and III.

First abdominal legs of the male :

first form, fig. 86 in front ; fig. 87 outside.

Antennal lamina, fig. 159, *a* ; epistoma, *b* ; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro lato, longo, lævi, profunde excavato, longissime acuminato, marginibus parallelis, ad acuminis apicem ciliatis ; acumine rostro longiori, angusto, acuto, recto, antennarum pedunculo longiori, basi utrinque spina valida ; cretis basalibus rostro coadunatis parallelis, modicis conicis, extus vix sulcatis, apice acutis. Antennis corpore paulo brevioribus, gracilibus, articulis basalibus elongatis, articulo primo dente externo longiori, acuto, articulo secundo dente parvo acuto ; antennis internis articulo basali dente medio infero acuto. Lamina longa, rostro æquali, angusta, ante medium latiori, deinde sensim attenuata, margine externo sinuato, inflato, apice acuto. Epistomate brevi, lato, antice obtuso-triangulari, angulis lateralibus rotundatis. Pedibus maxillariibus intus barbatis. Thorace cylindrico, cephalothorace supra longiori, lævi, sub-pubescente ; linea profunda, non sulcata, lateribus fissa, spina valida, acuta, intus barbata ; spina antica infera ad antennarum basin parva ; areola media nulla, antice spatio triangulari parvo, postice majori plana. Postabdomine thoracis latitudine, subtiliter punctato, segmentis antepenultimis angulo externo acutiori ; lamina media parte apicali breviori, antice leviter rotundata, media subsinuata ; parte basali apice utrinque spina unica valida. Pedibus anticis longis, gracilibus, depresso-cylindricis, subpubescentibus ; chela longa, angusta, subdepressa, marginibus parallelis, interno longo, recto ; digitis brevioribus, rectis, intus squamosis ; carpo longo, leviter oblique truncato, spina interna antica brevi, acuta ; subtus spina antica externa valida, acuta ; brachio longo, spina anteapicali acuta ; subtus spina interna antica, aliaque externa media brevioribus. Pedibus tertiis articulo tertio unguiculato ; pedibus quartis tuberculo perparvo basali, quintis capitulo basali annulari. Pedibus abdominalibus brevibus, validis, apice bifidis, contortis ; parte interna cylindrica, apice subito subangustiori, extus curva, laminata, obtusa ; parte externa fortiori, apice subito subangustiori, fusco cornea, intus curva, laminata, obtusa.

Long. corp. 2.8 ; antenn. 2 ; ped. antic. 2.

Patria : Root Pond, Mississippi.

Species valde insignis ; vidi marem unicum, Forma I., pedibus abdominalibus basi non articulatis, apice fusco corneis, rostro acumine longissimo.

Cat. No. 306, Root Pond, Miss., Mr. Wailes. Male Form I. Spec. 1.

15. CAMBARUS AFFINIS Say.

Astacus affinis Say, Journ. Philad. Acad., T. 1, p. 168, n. 3. — Harlan., Med. Physic. Researches, p. 230, fig. 2.

Figures on Pl. I., III., and V.

First abdominal legs of the male (full-grown *C. Pealei*):

first form, fig. 84 in front, fig. 85 outside.

Common size:

first form, fig. 19 in front, fig. 20 outside.

second form, fig. 21 in front, fig. 22 outside.

Antennal lamina, fig. 152, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

Pl. V. Full-grown female (*C. Pealei*) from Maryland, Havre de Grace.

MAS. Corpore pubescente; rostro lato, parallelo, basi media late excavata, utrinque ad marginem linea impressa, ciliata; acumine angusto, triangulari, acuto, parti dilatatae fere æquali, marginato, apice subrecurso, basi utrinque spina acuta longiori; cretis validis, extus sulcatis, parallelis, spina apicali longiori. Antennis validis thoracis longitudine; articulis duobus basalibus dente externo acuto longiori; antennis internis articulo basali dente infero medio acuto longiori; lamina longa, rostri longitudine, lata ad apicem attenuata, margine externo late inflato, spina apicali valida. Epistomate lato elliptico, basi angustiori. Pedibus maxillaribus externis intus, basi subtus villosis. Thorace ovoideo, punctato-pubescente, lateribus leviter, antice magis granulosis; cephalothoracis lateribus spinis nonnullis minoribus; linea profunda, vix sinuata, utrinque fissa, spina acuta, valida; spina apicali, infera, acuta; areola modica, plana, antice posticeque æque latiori. Postabdomine thorace longiori, lato, fere lævi, segmentis penultimis angulis externis subrectis; lamina media parte apicali breviori rotundata; parte basali utrinque apice bispina; lamina laterali usque ad marginem costata; lamina externa toto margine intermedio dentato. Pedibus anticis brevibus, chela brevi, angusta, depressa, punctato-ciliata, margine interno subrecto, serrato, margine externo lineato; digitis paulo longioribus, rectis, subcostatis, margine interno recto, spongioso; chela subtus parce punctata, digitis magis ciliatis. Carpo longo, oblique truncato, punctato-ciliato, spina media aliaque antica minori, internis acutis; subtus spinis duabus acutis validis. Brachio brevi, lævi, spinis duabus antepicalibus acutis validis, oblique positis; subtus spinis nonnullis validis, acutis, biseriatis. Pedibus tertiis articulo tertio articulato; pedibus quintis capitulo basali annulari. Pedibus abdominalibus, brevibus, validis, rectis, subcontortis, apice breviter bifidis; parte interna cylindrica, apice cornea, laminata; parte externa æquali, apice recurva, cornea, acuta.

Forma II. differt pedibus abdominalibus basi articulatis, apicibus nec fusco corneis, parte interna conica, acutiori, externa obtusiori recurva.

Femina differt ventre inter pedes quartos lævi; annulo obovato,

valido, lumine postico transversali, sulco antico longitudinali, fere bituberculato.

Long. corp. 3; antenn. 1.4; ped. antic. 1.9.

Very old specimens: Long. corp. 4.7; antenn. 2.8; ped. ant. 3.5.

Patria: Reading, Schuylkill River, Philadelphia; Pittsburg, Pennsylvania; New Jersey. Many very young specimens from the Niagara and Lake Erie. The very old specimens from New York; Havre de Grace, Maryland; from the Potomac at Washington; Carlisle, Pennsylvania.

The abdominal legs of the first form of the male vary a little in the shape of the interior tip, which is more or less acute. I have figured both; the more acute one is taken from the largest specimens, but it is also found in the younger. The obtuse tip is figured from one of intermediate age.

The young are similar to *A. propinquus* (*vide* that species).

The full-grown and very old specimens, described by Mr. Girard as *Cambarus Pealei*, differ in the following points:—

MAS. Corpore densius punctato-pubescente; rostro latitudine duplo longiori, leviter excavato, basi foveola lata, profundiori; marginibus lateralibus inflatis, spinis anteapicalibus validis, subrejectis; lamina antenarum margine externo subsinuato. Epistomate brevi, lato, antice obtuso-rotundato, angulis lateralibus acutioribus. Thorace lateribus magis granuloso; cephalothoracis spinis acutioribus; linea profunda, utrinque fissâ, spina duplici valida acuta aliisque minoribus; spina antica infera rejecta; areola punctato-ciliata. Pedibus anticis validis; chela forte ciliato-punctata, margine interno subincurvo, dentato, supra et subtus sulcato, digitis vix longioribus, planis, intus et digito mobili extus dentatis; carpo spina interna media valida; brachio spinis nonnullis anteapicalibus, nonnullisque minoribus anticis, omnibus acutis; subtus utrinque spina ad articulationem valida. Annulo feminae utrinque tuberculo ad sulcum longitudinalem valido.

Six very old and full-grown specimens from Havre de Grace, Maryland, agree so very well with the description given by Mr. Thomas Say, that they are doubtless *Astacus affinis* Say. A full-grown male from the Potomac, communicated by the Philadelphia Academy and labelled "*C. Pealei* Girard?" is identical with the specimens from Havre de Grace. Girard's species was from the Potomac, and "the fingers fasciate with green near the tips" are also described by Mr. Thomas Say. I have seen male and female from Reading, Schuylkill River, collected by Professor Baird, labelled as *C. affinis* Girard, and communicated as types from the Smithsonian collection by Professor W. Stimpson. The male belongs to the second form; the specimens are young, with only one lateral thoracic spine; in other respects they do not differ. I have no doubt that they are young of the species described above; Mr. Gi-

rard's description of *C. affinis* being made from specimens from Reading, and of *C. Pealei* from those of the Potomac, he was perhaps induced by this difference (though he does not say so) to refer the individuals to two species. The other differences given by him, namely, the longer antennæ, the broader area, the much less developed lateral spine of the rostrum, have no decisive value.

The *Astacus limosus* Rafinesque, Amer. Monthl. Mag., T. 2, p. 42, from the muddy banks of the Delaware, is apparently the same species, as quoted before by Mr. Girard. Rafinesque describes "a thorn of each flank" and gives the extreme dimensions "three to nine inches." I have seen specimens three inches long with only one thorn upon a side, and I have no doubt about their identity. The largest specimen seen by me is about five inches long. Nearly all younger specimens (three inches long) are bearded at their articulations, as quoted by Rafinesque; the larger specimens show much less hair. The description of *A. limosus* was published in November, 1817, of *A. affinis* in December, 1817, one month later. But the description of *A. affinis* is so perfect, that of *A. limosus* so imperfect, that it would be more suitable to retain the name given by Mr. Thomas Say, although the other has the priority.

The identity of *A. affinis* Erichs., Wieg. Archiv, T. 12, p. 96, n. 15, is probable. His description contains no different indication, but gives no security. *A. Bartonii* Milne Edw., Hist. Crust., T. 2, p. 331, n. 2, is apparently *C. affinis*. The typographical error in the quotation of the figures by Mr. Harlan has misled Mr. Milne Edwards, as Erichson remarks. The types of *A. Bartonii* Gibbes, in the Philadelphia Academy, are *C. affinis*.

Cat. No. 164, Havre de Grace, Md., Mr. T. R. Williams. Male Form I. Fem. Spec. 4.

Cat. No. 180, Havre de Grace, Md., Mr. T. R. Williams. Male Form I. Spec. 2.

Cat. No. 163, New Jersey, Mr. Abry. Male. Fem., young. Spec. 3.

Cat. No. 162, Schuylkill River, Pa., Mr. J. H. R. Male. Fem., young. Spec. 6.

Cat. No. 179, Niagara, N. Y., L. Agassiz. Male. Fem., young. Spec. 12.*

Cat. No. 177, Carlisle, Pa. Male. Fem., young. Spec. 2.

Cat. No. 270, New York, Mr. Pike. Fem. Spec. 1.

16. CAMBARUS VIRILIS *Hagen.*

Figures on Pl. I, II, III, and VIII.

Antennal lamina, fig. 155, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

First abdominal legs of the male:

first form, fig. 23 in front; fig. 24 outside; figs. 25, 26 variety, outside.

second form, fig. 27 in front; fig. 28 outside.

Inner sexual parts of the male:

first form, figs. 128, 129 side; fig. 132 viewed more from above.

second form, figs. 130, 131 side.

Pl. VIII. Male, first form: *a* variety A.

MAS. Rostro lato, fere duplo longiori, subexcavato, marginibus parallelis, antice vix convergentibus, punctato-lineatis; ante apicem utrinque subito sinuato, acumine triangulari, acuto, rostri latitudine non longiori, angusto, angulo basali laterali corneo, obtuso vel subacuto; cretis basilibus extus sulcatis, parum elevatis, parallelis, antice truncatis, subacutis. Antennis corpore brevioribus, articulis duobus basilibus dente externo, parvo, subacuto; antennis internis articulo basali dente infero medio acuto interno; lamina rostri longitudine, lata, margine externo inflato, apice brevi spinoso. Epistomate longitudine dimidio latiori, antice truncato, angustiori, acumine medio brevi, lateribus obliquis, subexcavato. (Forma epistomatis variabili, antice lateribusque margine vel recto, vel sinuato, vel exciso; angulis obtusis vel rotundatis.) Pedibus maxillaribus externis intus et subtus villosis. Thorace leviter ovato, subdepresso, parce sed distincte punctato, lateribus scabris, cephalothorace medio fere lævi; linea profunda modice sinuata, utrinque fissa, spina brevi, valida; spina antica infera subnulla; areola plana, punctata, medio angusta, postice magis dilatata. Postabdomine lato, thoracis longitudine, parcepunctato, segmentis penultimis angulo externo obtuso; lamina media parte apicali breviori, angulis rotundatis; parte basali apice sinuata, utrinque spinis duabus validis. Pedibus anticis brevibus, validis; chela lata, planiori, obsolete punctata, intus tuberculis biseriatis dentata; digitis dimidio longioribus, latis, planis, costato-lineatis, fortiter punctatis; interno recto, basi extus et intus tuberculoso-dentato; externo basi margine interno tuberculoso, subtus barbato, margine externo lævi, apice subincurvo; carpo latitudine vix longiori, extus oblique truncato, sublævi, spina interna media majori, aliaque basali minori; subtus spinis duabus anticis validis; brachio brevi, lævi, spinis duabus anteapicalibus oblique positis, obtusis; subtus spinis biseriatis acutis. Pedibus tertiis articulo tertio unguiculato; pedibus quintis capitulo basali brevi. Pedibus abdominalibus longis, subcontortis, longe bifidis, apice acutis, incurvis; parte externa longiori, basi crassiori; parte interna apice compresso-dilatata, acuta vel obtusiori.

Forma II. Pedibus abdominalibus basi articulatis, apicibus paululum divisis, crassioribus, cylindricis, minus incurvis.

Femina differt chelis minoribus; ventre inter pedes quartos lævi, anulo magno, fere cordiformi, fissura transversa, lata, profunda, margine tumido, antice fisso.

Variat interdum angulis rostri ad acuminis basin longioribus brevispinosus; rostri interdum angustiori, acumine longiori; lamina antennarum rostro longiori.

Long. 3.2; long. antenn. 2.4; long. ped. antic. 2.7.

Patria: Lake Superior; Lake Winnipeg; Saskatchewan and Red River, British America, and Toronto, Canada; Quincy, Illinois; Davenport and Burlington, Iowa; Miami River, Dayton, Ohio; Osage River, Missouri; Sugar River, Wisconsin (Mus. Salem); Texas.

I have seen the male of both forms from Lake Superior and from Illinois.

Var. A.

I have seen many full-grown male (Forma II.) and female examples from the Osage River, Missouri, and male and female from the Miami River, Dayton, Ohio, in the Philadelphia Museum, which I cannot yet separate specifically. The rostrum is smaller anteriorly, the thorax seems not so much dilated and less punctated, the areola is a little smaller; the fingers are more separated, the exterior more notched at the base interiorly; the carpus is trispinose beneath at the apex, the third spine is between the great middle interior spine and the two ordinary apical spines; the legs composing the third pair are not so much hooked, and those of the abdomen are similar to those of the second form described.

The male (Forma I.) and female from Davenport, Iowa, are in form and specific character doubtless identical with the examples from Lake Superior; but they agree more nearly with the specimens from the Osage River in the form of the rostrum and the greater development of the spines; the third spine on the carpus is more or less visible.

It is likewise impossible to separate the males and females from Texas. The rostrum is intermediate, but more similar to the Osage examples; the abdominal legs (Forma I.) are of the typical form; the carpus is trispinose, but in some examples from Lake Superior there is a similar third spine very little developed. One male is larger: Long. corp. 4.1; long. ped. antic. 3.7; long. chelæ, 2.2. In this male the fingers are more elongated.

The examples from Burlington, Iowa, are similar to the Texas examples. The male has a little hook at the third joint of the second pair of legs, but a similar monstrosity is not very uncommon. Accidentally the spines on the rostrum are more or less obliterated.

Cat. No. 1151, Lake Superior, L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 194, Lake Superior, L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 203, Lake Superior, L. Agassiz. Male Form II. Fem. Spec. 6.

Cat. No. 1828, Lake Winnipeg, British America, Mr. S. H. Scudder. Male. Fem. Spec. 12.*

Cat. No. 1829, Red River, British America, Mr. S. H. Scudder. Male. Fem. Spec. 12.*

Cat. No. 1830, Saskatchewan River, British America, Mr. S. H. Scudder. Male. Fem. Spec. 4.

Cat. No. 196, Quincy, Ill., Dr. Watson. Male. Fem. Spec. 12.*

Var. A.

Cat. No. 1831, Osage River, Dr. Stolley. Male Form II. Fem. Spec. 12.*

Cat. No. 1832, Osage River, Dr. Stolley. Male Form II. Fem. Spec. 12.*

Cat. No. 192, Osage River, Dr. Stolley. Male Form I. Spec. 1.

Cat. No. 171, Burlington, Iowa. Male Form I. Fem. Spec. 3.

Cat. No. 200, Texas, Dr. Stolley. Male Form I. Fem. Spec. 12.*

Cat. No. 207, Texas, Dr. Stolley. Male Form I. Fem. Spec. 4.

Cat. No. 1833, Davenport, Iowa. Male Form I. Fem. Spec. 3.

Dry Spec., Lake George, L. Agassiz. Male. Spec. 1.

17. CAMBARUS PLACIDUS *Hagen*.

Figures on Pl. I. and III.

First abdominal legs of the male :

first form, fig. 76 in front ; fig. 77 outside.

not articulated second form, fig. 78 in front ; fig. 79 outside.

Antennal lamina, fig. 158, *a* ; epistoma, *b* ; spine of the second joint of the exterior antenna, *c*.

This species is intermediate between *C. virilis* and *C. juvenilis*. It lives in the same localities, — Texas, Tennessee, and Quincy, Illinois. In its general form, more cylindrical thorax, smaller and more deeply sulcated rostrum, with the margins more thickened, it resembles *C. juvenilis* ; the abdominal legs of the male (Forma I. and II.) are very similar to those of *C. virilis*, though in one male the posterior hook is slightly evident ; nevertheless, the forehands are very dissimilar, more slender, much longer, not so much punctated, especially on the fingers, which are flattened ; the inner margin of the hands is very little tuberculated ; the fingers are more separated at the base, while the external one is not barbated ; a few females from Tennessee have little hairs, and are scarcely tuberculated at the inner margin, though sometimes they are much elongated ; the carpus is bispinose beneath, the spines often being very obtuse, especially the interior ones ; the biseriated

spines beneath the brachium, except the two apical ones, are nearly or quite obliterated, as in *C. juvenilis*. The external maxillary legs are not barbated beneath.

The largest male: Long. corp. 3.5; long. ped. antic. 2.5.

Patria: Lebanon, Tennessee; Quincy, Illinois; Texas.

I have seen more than twenty examples, male (Forma I. and II.) and female. In the males, Forma II., the abdominal legs are not articulated at the base.

Cat. No. 289, Lebanon, Tenn., Mr. J. M. Safford. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 296, Quincy, Ill., Dr. Watson. Male Form I. Spec. 1.

Cat. No. 170, Texas, G. Stolley. Male Form I. and II. Fem. Spec. 12.*

18. CAMBARUS JUVENILIS *Hagen*.

Figures on Pl. I. and III.

First abdominal legs of the male:

first form, fig. 29 in front; fig. 30 (Tab. II.) viewed more outwardly; fig. 31 outside.

second form, fig. 32 in front; fig. 33 outside.

Antennal lamina, fig. 157, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro angusto, longiori, sulcato, marginibus basi divergentibus, crassioribus, costato-lineatis; acumine triangulari, angusto, acuto, sinuato, spina utrinque brevi fusco-cornea, subrejeta; cretis subparallelis, vix elevatis, sulcatis, spina antica brevi, fusco-cornea. Antennis corpore paulo longioribus, articulo basali dente externo brevi, articulo secundo dente subnullo; articulo antennarum internarum basali dente infero acuto, magis apicali; lamina parva, rostro fere longiori, angusto, margine externo late inflato, apice longius spinoso. Epistomate lato, antice obtuso-angustiori, lateribus sinuatis, angulis basalibus paulo prominentibus. Pedibus maxillaribus externis intus summaque basi subtus villosis. Thorace fere cylindrico, subdepresso, punctato, punctis ad rostri basin profundis crebrioribus, lateribus leviter granulosis; linea modice profunda, vix sinuata, utrinque fissa, spina parva acuta; spina antica infera nulla; areola angusta, plana postice paulo latiori. Postabdomine thoracis latitudine, fere lævi, segmentis penultimis angulo externo obtuso; lamina media parte apicali breviori, rotundata, parte basali apice angustiori, sinuata, utrinque bispina. Pedibus anticis latis, brevibus; chela lata, depressa, ubique grosso-punctata, margine interno brevi, incurvo, tuberculis squamosis serrato; digitis longioribus, rectis, costatis, ad marginem internum lineato-punctatis, externo subtus basi barbato; carpo lato, extus oblique truncato, sublævi, spina interna media obtusa, subtus antice spinis duabus obtusis; brachio brevi, lævi spinis duobus obtusis anteapicalibus, oblique positus, subtus fere nudo, spinis duabus anticis. Pedibus tertiis articulo tertio unguiculato; pedibus quintis

capitulo basali brevi. Pedibus abdominalibus longis, subcontortis, longe bifidis, dente medio supero, partibus apicalibus gracilibus, spiniformibus, interna breviori, ante apicem sublatori.

Forma II. Differt pedibus abdominalibus brevioribus, basi articulatis, apice modo bifidis, partibus apicalibus inflatis, cylindricis, dente medio supero nullo.

Vidi mares adultos similes, sed pedibus abdominalibus basi non articulatis.

Femina differt abdomine latiori, chelis angustioribus, minus punctatis, sublævibus; venter inter pedes quartos nudo, fere plano; annulo magno, transverso, fissura transversa lata, profunda, antice bituberculata.

Long. corp. 2.5; antenn. 2.6; ped. chel. 1.8.

Patria: Little Hickman, Kentucky River; Osage River.

Vidi mares utriusque formæ, ac feminas, permultos.

This species is very similar to *C. virilis* Hag., but smaller, the thorax nearly cylindrical, more flattened above; the rostrum is smaller, deeply sulcated, with the margins thickened and laterally not so sharply rectangular, but more oblique; the three apical teeth are more developed; the antennal lamina is smaller, the hands throughout are punctated and more flattened, the spines of the carpus and brachium obtuse; the ordinarily biseriated spines beneath are not at all developed, except the two anterior.

Cat. No. 213, Little Hickman, Kentucky River, Mr. A. Hyatt. Male Form I. Fem. Spec. 12.*

Cat. No. 1834, Little Hickman, Kentucky River, Mr. A. Hyatt. Male Form II., first pair of abdominal legs articulated or not articulated. Spec. 12.*

Cat. No. 271, Osage River, G. Stolley. Male. Spec. 1.

19. CAMBARUS PROPINQUUS *Girard*.

Cambarus propinquus Girard, Proceed. Acad. Philad., T. VI. p. 88.

Figures on Pl. I. and III.

Antennal lamina, fig. 158³, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

First abdominal legs of the male:

first form, fig. 34 in front; fig. 35 variety; fig. 36 outside.

second form, fig. 37 in front; fig. 38 outside.

MAS. Rostro angustiori, elongato, subexcavato, marginibus parallelis, punctato-lineatis, apice utrinque sinuatis, spinis lateralibus parvis fusco-corneis; acumine triangulari, acuto, latitudine rostri longiori, supra leviter carinato; cretis basalibus brevibus, margine distantibus, parallelis, vix elevatis, sulcatis, antice truncatis. Antennis corpore brevioribus, dentibus articulorum basaliū brevibus acutis; antennis inter-
nis dente anteapicali infero interno acuto; lamina rostri longitudine,

apicem versus latiori, margine externo sinuato, modice inflato, apice spina longiori. Epistomate antice angustiori, truncato, dimidio latiori, lateribus excisis. Pedibus maxillaribus externis intus parum villosis, subtus nudis. Thorace subovoideo, parum-punctato, lateribus subtilissime granulosus; linea profunda, subsinuata, lateribus divisa, spina laterali acuta; areola plana, paulo latiori, antice posticeque æquo dilatata. Postabdomine thorace subangustiori, fere lævi, segmentis penultimis angulo externo mutico; lamina media parte apicali breviori, subangustiori, rotundata; parte basali quadrangulari, antice utrinque bispinosa. Pedibus anticis brevibus, chela modice lata, subdepressa, punctata, subtus lævi, margine interno brevi, recto, paululum serrato; digitis fere duplo longioribus, rectis, margine interno costato-lineatis, basi intus subdentatis. Carpo lato, oblique truncato, sublævi, spina media interna, subtus spina solum externa antica valida. Brachio brevi, lævi, spinis duabus anteapicalibus oblique positis, spinis inferis biserialis, duabus anticis exceptis subnullis. Pedibus tertiis articulo tertio unguiculato. Pedibus quintis capitulo basali cylindrico. Pedibus abdominalibus brevioribus, subcontortis, apice modo bifidis, partibus cylindricis, crassioribus, æqualibus, parte interna, apice subacuta paulo introrsus curvata, parte externa fusco-cornea, tenuiori, acuta.

Forma II. differt chela angustiori, crassiori, læviori; pedibus abdominalibus, basi articulatis (interdum non articulatis) partibus apicalibus æqualibus, parte externa non fusco cornea.

Femina differt chelis minoribus; ventre inter pedes quartos lævi, annulo obovato, subdepresso, fissura longitudinali dentata, apertura transversali nulla.

Long. corp. 2.6; long. ped. ant. 2.3.

Ordinarily, long. corp. 1.5 at 2.

Patria: Lake Oneida; Lake Superior; Niagara; Ogle County, Illinois; Delphi, Indiana; Rochester, N. Y.

I have seen many examples. In one abnormal male the third pair of legs are not hooked; some males have the third joint of the second pair of legs hooked.

A male type (Forma I.) found by Professor Baird on Grass River, St. Lawrence County, N. Y., and communicated by Professor Stimpson, is identical with the specimens from Lake Superior. Mr. Girard has seen specimens of this species from Lake Ontario, Garrison Creek, Sackett's Harbor, Four-Mile Creek, Oswego.

In one abnormal male the first pair of the abdominal legs are not developed, but they have the same shape as those of the females.

One male, Delphi, Indiana, is larger, long. corp. 3.2; ped. ant. 3.1, but very similar. The hands are more developed, as is commonly the case in old males; the abdominal legs are similar in form, but the posterior margin is a little hooked in the middle, and more emarginated

before the base. The rostrum is carinated as in the type. The identity is rendered much more probable, since I have seen from the same locality male and female types, both full grown and young, and the two forms of the male. In one male, nearly full grown, the rostrum is scarcely carinated at all.

Two males, Forma I., from Rochester, N. Y., were mixed with *C. obscurus*.

The very young and small specimens much resemble those of *C. affinis*. The rostrum is more acute, the thorns at the base of the acumen long and acute, the exterior margin of the antennal lamina sinuated, but the acumen is always a little carinated, and the hands are broader and shorter.

C. propinquus Gir. differs from *C. virilis* in having its rostrum carinated and narrower, with the acumen longer than broad; the cephalothoracic carinæ more distant from the margin; the lamina of the antennæ narrower, more acute; the maxillary legs without hairs externally; the carpus below with only one anterior spine, the brachium externally smooth; the inner margin of the chela straight; the areola broader, but not so much enlarged behind; the lamina media of the postabdomen more rounded. The angle of the cephalothoracic margin behind the eyes is almost obliterated.

Cat. No. 202, Lake Superior, L. Agassiz. Male Form II. Spec. 12.*

Cat. No. 1835, Lake Superior, L. Agassiz. Male Form I. Spec. 12.*

Cat. No. 206, Lake Superior, L. Agassiz. Fem. Spec. 12.*

Cat. No. 1836, Ugle County, Ill. Male. Fem. Spec. 6.

Cat. No. 1837, locality unknown. Male Form II., first pair of abdominal legs not articulated. Spec. 3.

Cat. No. 268, Delphi, Indiana, Mr. F. C. Hill. Male. Fem. Spec. 12.*

Cat. No. 205, Niagara, L. Agassiz. Male. Fem. Spec. 12.*

Cat. No. 247, Niagara, L. Agassiz. Fem. Spec. 1.

Cat. No. 185, Niagara, L. Agassiz. Male. Fem. Spec. 12.*

Cat. No. 1838, Rochester, N. Y., Professor C. Dewey. Male. Spec. 2.

Cat. No. 1839, Lake Oneida. Male. Spec. 3.

Dry Spec., Niagara, L. Agassiz. Male. Fem. Spec. 2.

20. CAMBARUS OBSCURUS *Hagen*.

Figures on Pl. I. and III.

First abdominal legs of the male.

first form, fig. 72 in front; fig. 73 outside.

second form, fig. 74 in front; fig. 75 outside.

Antennal lamina, fig. 154, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MALE. This species is very similar to *C. propinquus*, and I have seen the males from the same locality mixed in the same bottle. But hav-

ing compared many full-grown individuals, I find the following differences:—

Rostro non carinato, antice plano, vix angustiori; cretis basalibus brevioribus; lamina apice acutiori, margine externo non sinuato; epistomate antice magis truncato; chela latiori, planiori, margine interno incurvo, distincte biseriatis tuberculato, linea tuberculosa alia paululum distante versus basin mediam digiti mobilis; digitis brevioribus, latioribus, externo incurvo, basi magis distantibus; carpo subtus spinis anticis distinctis; pedibus abdominalibus margine postico medio dentato; parte interna lata recta, fere carinata, apice obtusa; postabdomine laminae mediæ parte apicali breviori.

Forma II., pedibus abdominalibus basi articulatis, margine postico non dentato; partibus magis inflatis, externa cylindrica obtusa.

Femina differt annulo apertura transversali antice bituberculata; tuberculo ventrali inter pedes secundos.

Long. corp. 3.5; antenn. 2.5; ped. antic. 2.5.

Patria: Genesee River, Rochester, N. Y.

Vidi 30 specimina.

This species is perhaps *A. fossor* Rafinesque, Amer. Monthl. Magaz., T. II. p. 42. The description is very short, and contains nothing contradictory, while the granular "gaping" toothed hand seems to designate this species rather than *C. propinquus*.

"*A. fossor*. Antennæ as long as the body, rostrum short, one-toothed on each side, a thorn behind the eyes; three pairs of spiniferous feet, hands of the first pair very large, granular-gaping-toothed, with a furrowed and bispinous wrist. Obs. Vulgar name, burrowing lobster, — communicated to me by Dr. Samuel L. Mitchell, — native of Virginia, Pennsylvania, and New York; size from four to six inches; it burrows in meadows and milldams, which it perforates and damages."

The dimensions are greater than in the specimens before me. Among the seven species known from New York, this species and *C. propinquus* are the only ones answering to Mr. Rafinesque's description. From Pennsylvania I know only *C. affinis* and *Bartonii*, from Virginia only *C. Bartonii* and *C. obesus*.

I do not know whether *C. obscurus* burrows in dams; should this peculiarity be made out, the name proposed by Mr. Rafinesque must be restored.

Cat. No. 181, Genesee River, Rochester, N. Y., Mr. H. A. Ward. Male. Fem. Spec. 12.*

Cat. No. 1840, Genesee River, Rochester, N. Y., Mr. H. A. Ward. Male Form I. Fem. Spec. 12.*

Cat. No. 1841, Genesee River, Rochester, N. Y., Mr. H. A. Ward. Male Form II. Spec. 3.

21. CAMBARUS RUSTICUS *Girard*.*Cambarus rusticus* Girard, Proc. Acad. Philad., T. 6, p. 88.

Figures on Pl. I. and III.

First abdominal legs of the male :

first form, fig. 80 in front ; fig. 81 outside.

second form, fig. 82 in front ; fig. 83 outside.

Antennal lamina, fig. 161, *a* ; epistoma, *b* ; spine of the second joint of the exterior antenna, *c*.

I HAVE heretofore considered the males and females from Cincinnati, Ohio, which belong to *C. rusticus* Gir., as a variety of *C. propinquus* ; the rostrum, however, is never carinated. The specimens are very closely allied to *C. placidus* ; still, the apex of the abdominal legs is nearly straight, while in *C. placidus* it is slightly incurved.

They are very similar to *C. propinquus*, though the rostrum is narrower and concave on the sides, the acumen shorter, the inner margin of the hand is incurved, the interior spine of the carpus less developed, while there are two apical spines beneath, the inner one being the smaller ; the brachium is more biseriated spinose beneath ; the fingers are more separated at the base ; the rostrum has the acumen excavated, not carinated ; the external part of the abdominal legs is a little longer ; the posterior margin hooked as in *C. obscurus* ; in the female there is a triangular lumen in the annulus ; the external parts of the two antepenultimate segments of the postabdomen are nearly rectangular.

Long. corp. 3 ; long. antenn. 2.6 ; long. ped. antic. 2.5.

Patria : Cincinnati, Ohio. I have compared a male type, Forma II., communicated by Professor W. Stimpson. I have seen nine examples, male, Formæ I. and II., and female. The abdominal legs in the Forma II. are not articulated at the base. One male from Lake Superior seems not to differ.

While this species is very near to *C. placidus*, the apical parts of the abdominal legs are shorter and more nearly straight. Nevertheless, the identity is not impossible. *C. obscurus* is very similar, but instantly separated by the truncated epistoma.

Cat. No. 285, Cincinnati, Ohio. Male. Fem. Spec. 12.*

Cat. No. 187, Lake Superior, L. Agassiz. Male Form I. Spec. 1.

22. CAMBARUS IMMUNIS *Hagen*.

Figures on Pl. I., III., and VIII.

First abdominal legs of the male.

first form, fig. 105 in front ; fig. 106 outside.

Antennal lamina, fig. 160, *a* ; epistoma, *b* ; variety, *d* ; spine of the second joint of the exterior antennæ, *c*.

Pl. VIII. Hand.

MAS. Rostro lato, dimidio longiori, supra excavato, lævi, basi foveola,

antice vallata, dense punctata, marginibus ad acuminis apicem elevatis, vix punctato-lineatis, antice convergentibus, apice leviter sinuatis, acumine brevi, triangulari, acuto, dentibus lateralibus nullis; cretis basilibus subdivergentibus, vix elevatis, extus sulcatis, antice muticis. Antennis gracilibus, thorace paulo longioribus, articulo basali dente externo parvo acuto, articulo secundo dente perparvo; antennis internis dente medio articuli basalis infero; lamina rostro vix longiori, lata, apice subtruncata, margine externo inflato, brevi-spinoso. Epistomate lato, apice exciso (vel truncato, spina media perparva), lateribus obliquis, angulis rotundatis. Pedibus maxillaribus externis intus et subtus villosis. Thorace subcylindrico, compresso, supra fortiter punctato, lateribus lævioribus; linea profunda, sinuata, lateribus divisa, spina utrinque parva, aliaque antica ad antennas infera minori; areola plana, punctata, angusta, postice valde dilatata. Postabdomine thoracis latitudine, lævi, segmentis antepenultimis angulo externo rotundato; lamina intermedia parte apicali vix breviori, rotundata, medio subexcisa; parte basali utrinque bispina. Pedibus anticis modicis, brevioribus; chela modice lata, depressa, leviter punctata, subtus lævi, extus marginata; margine interno brevi, subrecto, tuberculato-serrato; digitis longioribus, rectis, apice corneis, incurvis, supra costatis et punctato-lineatis; digiti mobilis margine externo serrato, interno basi exciso, tuberculato; digito externo tuberculo medio et basali minoribus, basi subtus valde barbata. Carpo lato, extus valde oblique-truncato, spina interna media majori, aliisque brevioribus; subtus antice et intus multispinoso, duabus anticis majoribus. Brachio brevi, lævi, margine supero parce tuberculoso, spinis duabus parvis anteapicalibus minoribus; subtus spinis obtusis biseriatis, anticis nonnullis majoribus. Pedibus secundis intus ante apicem valde barbatis. Pedibus tertiis articulo tertio unguiculato; pedibus quintis capitulo basali annulari. Pedibus abdominalibus modicis, contortis, longe bifidis, margine postico medio subito latiori, parte interna cylindrica, apice acuta, depressa, incurva, subdilatata; parte externa paulo longiori, acuta, incurva.

Femina differt chelis minoribus, pedibus secundis minus barbatis; ventre inter pedes quartos lævi, annulo obovali, fissura denticulata, apertura magna transversa; ventre inter pedes tertios tuberculo apicali planiori.

Long. corp. 2.6; long. antenn. 1.5; ped. antic. 2.

Vidi marem (ex Alabama) paulo majorem, chelis medio magis dilatatis, digito externo intus curvo.

Patria: Lawn Ridge and Belleville, Illinois; Huntsville, Alabama.

I have not seen the second form of the male.

A female from Beaufort, N. C., is a little smaller, the antennal lamina not so broad at the tip, the areola a little narrower, the hands are very small, the moving finger has its inner margin straight, without basal

excision; the example is otherwise similar to *C. immunis*; nevertheless, it possibly belongs to a different species.

C. immunis is a very interesting species; by its conical, short, and toothless rostrum it is allied to the group of *C. Bartonii*, by the abdominal legs of the male to the group of *C. affinis*. I have not seen young specimens; they, perhaps, possess lateral spines.

Cat. No. 188, Lawn Ridge, Ill., Mr. C. Ordway. Male. Fem. Spec. 5.

Cat. No. 1841, Belleville, Ill. Male. Spec. 1.

Cat. No. 301, Huntsville, Ala. Male. Spec. 1.

Cat. No. 1842, Beaufort, N. C., Mr. Bickmore. Fem. Spec. 1.

23. CAMBARUS EXTRANEUS *Hagen*.

Figures on Pl. I. and III.

First abdominal legs of the male :

second form, fig. 88 in front; fig. 89 outside.

Antennal lamina, fig. 156, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostrò lato, duplo vel triplo-longiori, lævi, excavato, marginibus punctato-lineatis, subparallelis vel subconvergentibus, utrinque ad apicem fortiter sinuatis; acumine longo, acuto, utrinque dente brevi, acuto; cretis parum elevatis, parallelis, sulcatis, spina acuta antica. Antennis validis (basis modo exstat), articulis duobus basalibus dente externo acuto, antennis internis articulo basali dente infero acuto; lamina rostri longitudine, modice lata, margine externo late inflato, apice spina acuta longiori. Epistomate brevi, lato, antice obtuso, rotundato, angulis lateralibus acutioribus; pedibus maxillaribus externis intus barbatis. Thorace leviter ovato, densius punctato-ciliato, lateribus granulosus, scabris; linea profunda, subfissa, utrinque spina valida acuta; spina antica infera ad antennarum basin; areola lata, plana, punctata, antice posticeque paulo dilatata, cephalothorace margine antico ad basin antennarum loco anguli dente parvo acuto. Postabdomine thoracis latitudine, paulo longiori, parce punctato, segmentis antepenultimis angulo laterali subrecto; lamina intermedia utrinque bispinosa, parte apicali breviori, rotundata. Pedibus anticis modicis; chela magna, lata, depressa, densius punctato-ciliata; margine interno longo, subrecto, biserialim tuberculato-dentato; digitis validis, planis longioribus, costato-lineatis, intus dentatis, basi subtus barbatis. Carpo lato, oblique truncato, parumpunctato, spina interna media majori, aliaque basali brevi; subtus spinis duabus anticis validis. Brachio longiori, lævi, spinis duabus anteapicalibus validis, oblique positis, subtus spinis acutis biserialis, spina ad articulationem utrinque valida. Pedibus tertiis articulo tertio unguiculato; pedibus quartis capitulo basali ovato, parvo. (Forma I. mihi invis.)

Forma II. Pedibus abdominalibus basi articulatis, validis, brevibus, contortis; parte interna cylindrica, brevi, apice acutiori recurva; parte

externa valida, antice impressa, apice compressa, dente valido recurvo, obtuso, intus duplici.

Vidi marem majorem pedibus abdominalibus non articulatis.

Femina differt abdomine latiori; ventre inter pedes quartos lævi, annulo transverso, lumine posteriori plano, sulco antico longitudinali, utrinque tuberculo rotundato.

Long. corp. 3.3; ped. antic. 2.

Habitat: Tennessee River, Georgia. The label is no doubt in part erroneous, as no portion of the Tennessee River flows through Georgia.

I have seen six specimens (three males, three females), of which the largest was a female. The males belong to Forma II., though the largest have the abdominal legs unarticulated. Apparently the males, Forma I., have larger hands and a more finished sculpture. In all the specimens the whole animal is punctuous-ciliated. The thorax is a little shorter than the abdomen.

A. affinis Say differs in having a double spine on each side of the thorax, in the very unlike forms of the abdominal legs, in the absence of the thoracic marginal spine behind the eyes, and in its larger areola. I cannot discover this species in Mr. LeConte's monograph.

It is possible that the larger female belongs to a different species; the five others are identical, the rostrum being visibly attenuated before, the acumen shorter, and the area broader. This female seems very near *C. affinis* Say. The species itself is very remarkable in having the abdominal legs formed exactly as in the group of *C. Bartonii*.

Cat. No. 175, Tennessee River, (near the borders of?) Georgia, Colonel Jones and Dr. Daniell. Male Form I. and II. Fem. Spec. 6.

III. GROUP. (TYPE *C. BARTONII*.)

The third legs of the males hooked; rostrum short, toothless; first pair of abdominal legs with the tip of the exterior part recurved, the tip of the interior part short.

This group, perhaps, unites two groups of co-ordinate value. It is, of course, possible that an examination of a greater number of specimens of *C. Carolinus* and other allied species would allow us to place them in another different group.

1. *C. Bartonii* and the allied species (except *C. Carolinus* and *C. advena*) form a very natural group. Hooks only occur in the males on the third pair of legs. The rostrum is short, broad, obtuse at the tip and toothless, even in the young animals. The antennæ are shorter than the body; their lamina is short and dilated near the tip; the spine beneath the first joint of the inner antennæ is more apical; the flagellum is short, the inner branch a little more slender, shorter, and the joints are sometimes more calcareous and fragile, similar to those of the true

Astacus. The foreborder of the cephalothorax is strongly angulated. The body, especially the postabdomen and the hands, is broader. The first pair of abdominal legs of the male has a peculiar and striking development. The tip of the exterior part forms a larger and more strongly recurved tooth; the tip of the interior part is broken, short, and conical. The second pair of legs and the third are ciliated with hairs. Burrowing habits are observed in *C. Diogenes* (united by me with *C. Bartonii*).

2. The other group, *C. Carolinus* and *C. advena*, differs in having the front border of the cephalothorax not angulated, the very narrow postabdomen, and principally in the form of the first abdominal legs, similar to those described in *C. acutus*.

SYNOPSIS OF THE SPECIES.

1st SECTION.

Front border of the cephalothorax angulated; first abdominal legs strongly hooked.

A. Areola linear: *C. obesus*, *C. Nebrascensis*.

B. Areola broad: *C. Bartonii* (with *C. pusillus*, *C. montanus*, *C. longulus*, *C. Diogenes*), *C. robustus*, *C. latimanus*.

Incertæ sedis: *C. Mexicanus*, *C. Cubensis*.

2d SECTION.

Front border of the cephalothorax straight; first abdominal legs not hooked: *C. advena*, *C. Carolinus*.

The determination of the species in this group is not so certain as in the foregoing groups. In some species the entire lack of typical specimens, or the insufficiency of materials, has perhaps misled me and occasioned errors.

This is especially the case in the species united by me with *C. Bartonii*, viz. in *C. pusillus*, *C. montanus*, *C. longulus*, and *C. Diogenes*. More ample material will either confirm my views or correct my errors.

24. CAMBARUS BARTONII *Fabricius*.

Astacus Bartonii Fabr., Supplem. Ent., p. 407, n. 3. — Bosc., Hist. Nat. Crust., T. II. p. 40. — Latr., Hist. Nat. Crust., T. VI. p. 240. — Say, Journ. Acad. N. Sc. Philad., T. I. p. 167, 2. — Harlan, Med. and Phys. Research., p. 230, fig. 3. — Erichson, Archiv. T. XII. p. 97, n. 17. — DeKay, N. Y. Zoölogy, VI. 22, Pl. 8, fig. 25.

Figures on Pl. I., II., and III.

First abdominal legs of the male:

first form, fig. 47 in front; fig. 48 outside.

second form, fig. 49 in front; fig. 50 outside.

Inner sexual parts of the male:

first form, fig. 135; side, fig. 136.

second form, fig. 137; side, fig. 138.

Inner sexual parts of the female, fig. 139.

Antennal lamina, fig. 166, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro brevi, lato, fere quadrangulari, ante apicem utrinque

subito sinuato, acumine latitudine rostri breviori, acuto; supra fere plano, marginibus antice ad acuminis apicem elevatis; basi foveola latiori, punctata; cretis basalibus parvis, vix rostro separatis, parallelis, extus linea punctata impressis, antice subacutis. Antennis corpore brevioribus; articulo basali dente parvo, acuto; antennis internis articulo basali spina infera antica acuta. Lamina brevi, angusta, rostro sublongiori, apice angustiori, margine externo latius inflato, apice spina longiori, acuta. Epistomate semicirculari, spina media antica; pedibus maxillaribus externis intus barbatis. Thorace subcylindrico, paulo depresso, postice subangustato, punctato, lateribus granulato; cephalothorace medio lævi; linea profunda, sinuata, spina parva infera antica ad antennarum basin; areola modica, plana, punctata, postice latiori. Postabdomine vix angustiori, punctato, segmentis antepenultimis angulis rotundatis; lamina media bispina; parte apicali æquali elliptica. Pedibus anticis brevibus, modicis; chela lata, subinflata, punctata; margine brevi dentato, interdum biseriatim tuberculato, recto, subtus sulcato; digitis validis basi non claudentibus, costatis, fortiter punctato-lineatis, dimidio longioribus, rectis, paululum subtus curvatis, intus dentatis. Brachio brevi, lævi, ante apicem supra obsolete-tuberculoso, subtus spinis biseriatis acutis. Carpo lato, oblique truncato, rarius punctato, spina media interna majori, aliaque basali minori; subtus spinis duabus anticis obtusis. Pedibus secundis densius ciliatis; pedibus tertiis articulo tertio unguiculato; pedibus quartis capitulo basali ovali. Pedibus abdominalibus brevibus, validis, contortis, subtus medio depressis, parte interna cylindrica, apice acuta, incurva; parte externa longiori, latiori, intus plana, apice dente separato, compresso, longo, incurvo, margine externo fusco-corneo, striato.

Forma II. differt chela angustiori, digitis longioribus, sæpe basi claudentibus. Pedibus abdominalibus brevibus, validis, contortis, basi articulatis, parte interna brevi, cylindrica, apice extus curvata ac subito acuminata; parte externa latiori, intus plana, apice dente magno, obtuso, recurvo, compresso, intus duplici. Variat pedibus basi non articulatis, chela perparva, digitis fere cylindricis; carpo interdum spina interna media singula.

Femina differt chelis minoribus; ventre inter pedes quartos lævi; annulo cordiformi, lumine transverso postico, sulcoque angusto antico longitudinali; abdomine latiori, summa basi angustato.

Long. corp. 2.8 – 3.6; antenn. 1.5 – 3.8; ped. antic. 2 – 2.5

Patria: Lake Superior; Lake Champlain, Burlington, Vermont (Salem Museum); Elizabethtown, Essex County, and Berkshire, Tioga County, Fishkill and Newburg (Rafinesque), N. Y.; Schooley's Mount, New Jersey; Schuylkill River, Philadelphia, and Berwick, Pennsylvania; Cincinnati, Scioto River, Columbia, Ohio; Hickman's Landing, Kentucky River; Georgetown, D. C.; Osage River, Missouri; Georgia; Greenbrier River, Virginia.

I have seen more than four hundred specimens, both very young and very old. The shape of the rostrum is variable, sometimes broader and quadrangular; the sculpture is different, the oldest individuals are most strongly tuberculated; the antennæ are shorter than the abdomen, though in one male (the largest seen by me) they are a little longer than the abdomen. The hands are variable in form, often very broad, and the fingers much separated at the base; the abdominal legs in the second form are often not articulated.

It is possible that *A. Bartonii* Fabr. belongs to this species; the description contains no contradictory characters. The description by Bosc is too short, and his figure too imperfect to afford any help. The species of Say, Harlan, Erichson, are apparently identical. DeKay's (N. Y. Fauna, T. 6, p. 20, T. 8, fig. 25) description is very brief and the figure poor, still I think the species the same. *A. affinis* M. Edwards seems to be the same (Crust. II. p. 332, n. 3). *A. Bartonii* M. Edwards is *C. affinis*. I do not know whether M. Edwards has seen the type of Bosc.

Girard gives (Proc. Acad. Philad., No. 8, T. 6, p. 88) no description of his *Bartonii*, but he quotes the works above-mentioned. Girard cites as identical *A. ciliaris* Rafinesque (Amer. Month. Mag. II. No. 3, p. 42), and this is possibly true of very large specimens.

Girard describes (l. c. p. 90, n. 13) *A. pusillus* Rafin. The description by Rafinesque (l. c. No. 4, p. 42) is too short, "the rostrum oval acute," and "wrist smooth," being the only important characters given. The comparative description by Girard is not sufficient, though the Cambridge Museum possesses one female from Lake Champlain by Professor Baird, possibly the *A. pusillus* Rafinesque.

I suppose that *C. pusillus* does not differ from *A. Bartonii*, because the examples from the North, Lake Superior, and other localities are always very small. The external lamina of the postabdomen has the inner third of the apical margin of the basal part not denticulated; in *C. obesus* it is entirely denticulated. Cilia evidently occur on the second pair of legs, and justify the name given by Rafinesque. The basal inner angle of the hand is nearly rectangular.

I have seen a female from the Mammoth Cave, Kentucky, with the eyes well developed, and a female from Georgia.

In the largest male from Ohio the antennæ are longer than the body, — a character given for *C. montanus* Girard, — but the areola is not broader.

I have compared a female type from Berwick, Pennsylvania, labelled *C. Bartonii* Er., and communicated by Professor Stimpson. The specimen is from the locality mentioned by Mr. Girard and identical with the specimens described by me from Schuylkill River.

I have also compared *Cambarus montanus* Girard, l. c. p. 88, male type from Greenbrier River, Virginia, communicated by Professor Stimp-

son. It is a young male of the second form, with the abdominal legs articulated. The animal is identical with *C. Bartonii*, and the shape of the epistoma forbids us to regard it as a young *C. latimanus*. The external lamina of the postabdomen has the inner third of its margin not denticulated. A dry male specimen from Virginia, *C. montanus*, Acad. Philad., is identical with the foregoing, the abdominal legs exactly resemble those of *C. Bartonii*. In the Cambridge Museum there is a jar with alcoholic specimens labelled, Isle of Pico, Azores, presented by Mrs. Dabney. It contains one *Alpheus* and three *C. Bartonii*. It seems very doubtful at present that these *Cambari* are from the Azores. The types in the Cambridge Museum of *A. Bartonii* Gibbes, mentioned in his Fauna of South Carolina, belong to *C. latimanus*. The types of *C. Bartonii* in the Mus. Acad. Philadelphia, from Pennsylvania and Pittsburgh, also determined by Mr. L. R. Gibbes, are *C. affinis* Say.

A female type of *C. longulus* Gir., Proc. Acad. Philad., T. 6, p. 90, communicated by Professor Stimpson, is from the Middle States; it differs from *C. Bartonii* in having its hands smooth, very large, and apparently deformed. The fingers are small and unusually far separated at the base. In the space between them is a large bunch of hairs. I have not found such a bunch of hairs in any specimen of *C. Bartonii*; perhaps there was more room for the growth of these hairs in this deformed specimen. But I should remark that specimens of *C. Bartonii*, with the fingers about as widely separated, are destitute of any such tufts. I have sometimes found hairs in this place, but never so many in *C. latimanus*. Nevertheless, the other characters show that it must be *C. Bartonii* or a new species. I think it is *C. Bartonii*.

C. Bartonii is the most variable species; as yet I cannot find stable and constant characters for dividing them into three or four species, as Mr. Girard has done. The rostrum is often nearly quadrangular, with a little tooth in the middle of its front border, and varies in being more elongated, more attenuated before, with the angles more or less rounded and the apical tooth longer or shorter, broader or narrower. The lamina of the antennæ varies in breadth, principally in front, and in the length of the apical spine. The epistoma is often triangular, acute, often more rounded laterally, sometimes more obtuse at the tip and nearly truncated in front. The dorsal areola varies in specimens from the same locality (Cincinnati from $\frac{2}{60}$ to $\frac{8}{60}$ inches). The form of the hand is exceedingly variable, the fingers being often broadly separated at their base, frequently nearly contiguous.

The type of *C. montanus* does not differ from the typical form. The length of the antennæ quoted by Girard is variable. One male from Cincinnati, with the most quadrangular rostrum, has the antennæ even longer than the body.

I have seen more than one hundred specimens from Lake Superior,

Lake Champlain, and from the Aquarial Gardens in Boston (locality uncertain, but perhaps from the Northern Lakes), which belong undoubtedly to *C. pusillus*; still the differences given by Mr. Girard are not sufficient for separating *C. pusillus* from *C. Bartonii*.

The type of *C. longulus* is, as I think, merely an accidental variety of *C. Bartonii*. The fingers are cylindrical, very widely separated at the base, and bearded in this place and inside of the external finger, along the basal half. The shape of the finger is unusual and, I think, accidental. Broadly separated fingers are sometimes seen; the Museum possesses a specimen having the fingers on the right hand separated and those on the left hand contiguous; but I have never seen the space between the fingers bearded with hairs. The other differences quoted by Mr. Girard, and taken from the shape of the rostrum and the breadth of the areola, are not important enough to warrant a specific separation.

Mr. Say, Journ. Acad. Philad., T. 1. p. 443, says: "*A. Bartonii* has the hands differently proportioned with respect to the thumb, and more or less muricated. They are extremely common in the pine barren marshes of the Southern States, and particularly in those of Georgia and Florida." I have not seen specimens from there, but they perhaps belong to *A. latimanus*.

Cat. No. 1847, Aquarial Garden, Boston, L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 284, Berkshire, Tioga County, N. Y., L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 278, Schooley's Mount, N. Y., Mr. A. Mayor. Male. Fem., young. Spec. 8.

Cat. No. 290, Elizabethtown, N. Y., Professor Baird. Male Form II. Fem. Spec. 3.

Cat. No. 231, Lake Champlain, Professor Baird. Fem. Spec. 1.

Cat. No. 227, New Jersey, L. Agassiz. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 235, Schuylkill River, Penn., L. Agassiz. Male. Fem. Spec. 12.*

Cat. No. 238, Philadelphia, Penn., Dr. Leidy. Male Form I. and II. Fem. Spec. 12.*

Cat. No. 244, Lake Superior, L. Agassiz. Male Form II. Fem. Spec. 12.*

Cat. No. 243, Cincinnati, Ohio. Male Form II. Fem. Spec. 3.

Cat. No. 267, Cincinnati, Ohio. Male Form II. Fem. Spec. 3.

Cat. No. 288, Cincinnati, Ohio, L. Agassiz. Male. Fem., young. Spec. 12.*

Cat. No. 295, Scioto River, Columbia, Ohio, Mr. J. Sullivan. Male Form II. Fem. Spec. 6.

Cat. No. 286, Mammoth Cave, Kentucky. Fem. Spec. 1.

Cat. No. 240, Hickman's Landing, Kentucky River, Mr. A. Hyatt. Fem. Spec. 1.

Cat. No. 183, Osage River, Mr. Stolley. Male Form II. Fem. Spec. 8.

Cat. No. 237, Georgetown, D. C., Lanman. Male Form II., the first pair of abdominal legs not articulated. Spec. 1.

? Cat. No. 1101, Pico, Azores, Mrs. Dabney. Male. Fem. Spec. 4. (The last locality is apparently erroneous.)

Dry spec., Niagara, L. Agassiz. Male. Spec. 1.

25. CAMBARUS ROBUSTUS *Girard*.

Cambarus robustus Girard, Proc. Acad. Philad., T. 6, p. 90.

Antennal lamina, fig. 156, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

C. Bartonii similis, sed differt: rostro excavato, longiori, antice angustiori, acumine triangulari, rostri latitudine longiori; lamina antennarum longiori, antice latiori; articulo antennarum secundo dente externo acuto; epistomate triangulari, lateribus paulo rotundatis; thorace subovato; linea thoracica spina utrinque laterali; chela margine interno serie duplici tuberculorum serrata, digito externo supra ac subtus impresso, excavato; carpo tuberculo parvo inter spina antica et illa anteriori marginis interni.

Long. 3.2; antenn. 2.5; ped. ant. 2.

Habitat: Toronto, Humber River; Genesee River, Rochester, and Lake Regis, N. Y. Two females from Fredericksburg, Virginia (Salem Mus.).

I have seen one typical male, second form, from Toronto, in the Philadelphia Academy, and some specimens from New York, both forms of the male and female, all full grown. The abdominal legs of the male have somewhat more resemblance to those of *C. latimanus*. The rostrum and the hands, the external finger of which shows a very visible impression, separate this species from *C. Bartonii*.

C. obesus differs constantly in the linear areola. *C. latimanus* has no lateral thoracic spine, a more rounded thorax, the carpus beneath strongly tuberculated on the inner side; besides the different and more elongated rostrum, and the rounded not impressed under side of the external finger.

Cat. No. 176, Genesee River, Rochester, N. Y., Mr. H. A. Ward. Male Form. II. Fem. Spec. 12.*

Cat. No. 1176, Western New York, L. Agassiz. Male. Spec. 4.

26. CAMBARUS OBESUS *Hagen*.

Figures on Pl. I., III., and IX.

First abdominal legs of the male :

first form, fig. 39 in front ; fig. 40 outside.

second form, not articulated, fig. 41 in front ; fig. 42 outside.

Antennal lamina, fig. 163, *a* ; epistoma, *b* ; spine of the second joint of the exterior antenna, *c*.

Pl. XI. Male, first form.

MAS. Rostro lato, brevi, latitudine paululum longiori, antice angustiori, acumine brevi, late triangulari, acuto ; rostro supra excavato, lævi, marginibus subito elevatis, ad acuminis apicem non interruptis ; foveola basali latiori ; cretis subdivergentibus, obsoletis, extus punctato-sulcatis, antice muticis postice calloso-inflatis. Antennis validis, thorace vix longioribus, articulis basalibus dente externo subnullo ; antennis internis articulo basali dente medio infero parvo ; lamina brevi, angusta, intus non dilatata, margine externo latius inflato, spina apicali longiori. Epistomate longitudine vix latiori, elliptico, angulis externis obtusis ; pedibus maxillaribus externis intus barbatis. Thorace valido, cephalothorace supra punctis profundis rarioribus, lateribus sparsim granulosis ; mesothorace compresso, supra depresso, subtilissime punctato, punctis profundis rarioribus sparsis, lateribus vix granulato ; linea profunda, sinuata, antice spina ad antennarum basin infera nulla ; areola nulla, linea intermedia profunda ; spatio triangulari postico latiori. Postabdomine lato, segmentis anteapicalibus angulis externis rotundatis ; lamina media bi- (vel tri-) spinosa, parte apicali æquali elliptica. Pedibus anticis longis, validis ; chela magna, latissima, subdepressa, lævi, punctis rarioribus ; margine interno brevi, incurvo, forte biserialim tuberculato ; margine externo incurvo, punctato-lineato ; digitis plus duplo longioribus, latis, costatis, profunde bilineato-punctatis ; interno basi intus exciso, dimidio basali extus et intus tuberculato ; externo triangulari, basi forte depresso, acutiori, tuberculis majoribus basalibus internis ; supra ad marginem externum dense exsculpto. Carpo lato, oblique truncato, lævi, punctis nonnullis profundis, tuberculis internis rarioribus, subantico majori ; subtus lævi, spinis duabus anticis obtusis. Brachio valido ; lævi, tuberculis nonnullis anteapicalibus, duabus oblique positis majoribus ; subtus spinis obtusis biserialis. Pedibus tertiis articulo tertio unguiculato ; pedibus quartis capitulo basali compresso ovali, quintis subnullo. Pedibus abdominalibus brevibus, validis, contortis ; intus latis, planis ; parte interna breviori, apice conica, extus curvata ; parte externa longiori, apice intus curvata compressa, dente lato, fusco corneo, striato, intus duplici, valde incurvo.

Forma II. Differt chelis minoribus, unguiculis parvis ; pedibus abdominalibus non articulatis, parte interna conica, longiori ; parte externa apice nec fusco cornea, nec striata, obtusa incurva.

Femina differt antennis brevioribus, chelis minoribus, ventre inter

pedes quartos lævi, annulo transverso inflato, apertura media profunda transversali; postabdomine latiori, basi summa angustiori.

(Maxim.) Long. corp. 4.5; antenn. 2.6; ped. antic. 4.

Habitat: Evanston, Lawn Ridge, and Belleville, Illinois, and the prairies near Chicago (Philad. Acad.); Petersburg, Va.; Monticello, Miss.; Arkansas; New Orleans; Kelley's Island, Ohio; Lake Erie; Lake Michigan; Garrison Creek; Sackett's Harbor; Lake Ontario.

Vidi 16 specimina. The Salem Museum contains a full-grown male and a very young male of the second form, the abdominal legs not being articulated.

C. obesus is very similar to *C. latimanus*, but the "areola nulla" always separates them instantly. The thorax is more ovoid than in *C. latimanus*. The epistoma is not pointed anteriorly, the second joint of the external antennæ has no spine; the carinæ are posteriorly callosso-inflatae.

One female (Garrison Creek, Philad. Acad.) was labelled *C. propinquus*? but the type of *C. propinquus*, communicated by Professor Stimpson, is a different species.

I have not seen the *C. diogenes* Girard. Although he treated of it at some length, he left it without an accurate description. The dorsal lines of the carapace are almost contiguous, so that the areola is almost wanting. I am in doubt whether it can be referred to *C. obesus*. The only specimen, from Georgetown, D. C., in the Museum is *C. Bartonii*. Perhaps *C. Diogenes* is also *C. Bartonii*.

A specimen from the District of Columbia, labelled *C. Diogenes*, in the Museum of the Philad. Acad., does not agree at all with the description of Mr. Girard, and is *C. propinquus*.

A single female from New Orleans differs in having a narrower rostrum, with the margins parallel and the tip more acute. The first pair of abdominal legs, ordinarily bearded at the margins and flattened, are singularly transformed. They are thicker, cylindrical, with the tip narrower and twisted, as is the case with the abdominal legs of *Astacus fluviatilis*. The postabdomen is narrower at the base. Possibly this specimen is a sterile female.

Another female, in shape and size similar to the foregoing (3.2 inch. long) has the rostrum broader, the margins not so much thickened as in the type, the acumen more acute. The hand is more flattened and not so strongly dotted, the inner margin more rounded, with six strong and separated teeth, giving to the specimen a very peculiar aspect. The two anterior spines of the inner margin of the carpus are long and more developed. The annulus between the fourth pair of legs has its anterior margin irregularly tuberculated. The right hand is wanting; I regard the specimen as abnormal and deformed.

Cat. No. 165, Belleville, Ill., Dr. Engelmann. Fem. Spec. 2.

Cat. No. 1461, Evanston, Ill. Male. Spec. 1.

- Cat. No. 195, Lawn Ridge, Ill., Mr. A. Ordway. Fem. Spec. 1.
 Cat. No. 197, Lawn Ridge, Ill., Mr. A. Ordway. Male. Fem. Spec. 6.
 Cat. No. 1848, Petersburg, Va. Fem. Spec. 1.
 Cat. No. 229, Arkansas, Mr. G. Stolley. Male. Spec. 1.
 Cat. No. 242, New Orleans, Mr. Lawrence. Fem. Spec. 1.
 Dry Spec. Lake Michigan, Professor C. Marey. Fem. Spec. 1.

27. CAMBARUS NEBRASCENSIS Girard.

Cambarus Nebrascensis Girard, Proc. Philad. Acad. N. Sc., No. 10, T. 6, p. 91.

"ROSTRUM intermediate in form between that of *C. robustus* and *C. Diogenes*." "Dorsal lines of suture of the carapace in close contiguity. Large claw nearly conical, giving to the species a very peculiar aspect."

"Fort Pierre, Nebraska; collected in 1850 by Thaddeus Culvertson."
 — Girard.

I have never seen any *Cambarus* agreeing with the description given by Mr. Girard, and I have not seen a typical specimen of *C. Diogenes*, the species compared with *C. Nebrascensis*. I have spoken of all the species of *Cambarus* with a linear areola under *C. maniculatus*. None of these several species agrees with the description given of *C. Nebrascensis*.

28. CAMBARUS LATIMANUS Le Conte.

Astacus latimanus LeConte, Proc. Acad. Philad. N. Sc., T. 7, p. 402.

Figures on Pl. I. and III.

First abdominal leg of the male :

first form, fig. 43 in front; fig. 44 outside.

second form, fig. 45 in front; fig. 46 outside.

Antennal lamina, fig. 162, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro brevi, basi lato, tum sensim angustiori, fere triangulari, ante apicem leviter sinuato, acumine brevi, acuto; rostro supra excavato, basi foveolato; marginibus lineato punctatis; acumine vix marginato; cretis parvis, postice subdivergentibus, extus linea impressa, antice obtusis. Antennis gracilibus, thorace longioribus, articulis duobus basalibus dentibus externis parvis acutis; antennis internis articulo basali dente infero anteapicali parvo; lamina brevi, angusta, apice latiori, margine externo inflato, spina acuta apicali. Epistomate latiori, antice truncato, spina parva media; lateribus obliquis, angulis obtusis; pedibus maxillaribus externis intus barbatis. Thorace leviter ovato, parce punctato, lateribus granulosus vel tuberculosus; linea profunda, sinuata, spina utrinque laterali modica vel obsoleta; spina antica infera subnulla; areola modica, plana, antice paululum carinata, postice latiori. Postabdomine vix angustiori, lævi, segmentis anteapicalibus angulis ex-

ternis obtusis; lamina media parte utrinque bispina, parte apicali, sublongiori, elliptica. Pedibus anticis brevibus, latis; chela lata plana, ciliato-punctata; subtus lævi, ad marginem internum sulcata; margine interno brevi, incurvo, tuberculoso-serrato; digitis duplo longioribus, latis, rectis, bicostatis, lineato-punctatis, ciliatis; digito mobili extus et basi intus tuberculato; digito externo basi intus tuberculato, extus marginato, punctato. Carpo lato, oblique truncato, parce punctato, intus subtuberculoso, spina interna media valida, interdum alia basali parva; subtus spinis duabus obtusis anticis, tertia minori interna. Brachio brevi, lævi, spinis duabus anteapicalibus oblique positis, subtus spinis biseriatis acutis. Pedibus tertiis articulo tertio unguiculato; quartis capitulo basali, ovoideo, quintis subnullo. Pedibus abdominalibus brevibus, validis, contortis; intus latis, planis; extus medio crassioribus; parte interna breviori, cylindrica, apice inflexa, conica, acumine parvo, compresso; parte externa dente longo apicali subito incurvo, extus fusco-corneo, striato.

Forma II. differt chela plerumque læviori; pedibus abdominalibus basi articulatis; parte interna apice obtusiori; parte externa dente apicali latiori, vix separato, breviori, obtuso, extus nec fusco-corneo nec striato.

Marem vidi magnum pedibus abdominalibus similibus sed basi non articulatis; chelis magnis, lævioribus, digitis angustioribus.

Femina differt abdomine latiori, basi angustato; ventre inter pedes quartos nudo; annulo transverso, modice crasso, lumine denticulato posteriori, sulco anteriori longitudinali.

(Maxim.) Long. corp. 2.9; antenn. 2.5; ped. antic. 2.3.

Habitat: Athens, Georgia; South Carolina.

Vidi specimina multa et juniora.

Juniores læviores, acumine variabili, rostro interdum longiori.

I have examined a female type in the Mus. Acad. Philad. of *C. latimanus* LeConte. It is the largest seen by me, and has the dimensions given by Mr. LeConte, long. corp. 3.3.

Cat. No. 236, Athens, Ga., Dr. J. LeConte. Male. Fem. Spec. 12.*

Cat. No. 1849, Milledgeville, Ga. Male. Spec. 1.

Dry Spec., South Carolina, Mr. L. R. Gibbes. Male. Spec. 1; labelled *A. Bartonii* Gibbes.

29. CAMBARUS MEXICANUS *Erichson*.

Cambarus Mexicanus Erichson, Wiegmann's Archiv, No. 20, T. 12 p. 99.

"CHELIS granulatis, gracilibus, subcylindricis, carpis muticis, rostro lato, apice obtusiusculo."

"Thorax somewhat compressed, always densely punctulated; cretæ prominent, divergent behind; rostrum nearly flat, broad, obtuse at the

apex, with sharply recurved margins; lamina of the antennæ broad, with a little apical external spine. Hands narrow, nearly cylindrical, densely scabrous; the fingers a little shorter than the hands, thin; carpus longer than broad, scabrous, without spines on the inner side and beneath. Postabdomen nearly as broad as the thorax. The third pair of legs in the male hooked. Long. corp. nearly 2 inch. Mexico." — Erichson.

I have not seen this species. The hands resemble in shape those of *C. Nebrascensis*.

C. Montezumæ Saussure, Revue et Magas. Zool., T. 9, p. 102, and Mém. Soc. Phys. Genève, T. 14, Pl. II. fig. 22, p. 459, from the marshes of the valley of Mexico, Chapultepec, seems to be the young of *C. Mexicanis*. It is always difficult to identify or to separate species by the descriptions, but I cannot find any difference in the description given by Mr. DeSaussure. It is said that the males of *C. Montezumæ* have hooks on the second and the third pair of legs, and I have seen the same aberration in some species of this group.

30. CAMBARUS CUBENSIS *Erichson*.

Cambarus Cubensis Erichson, Wiegmann, Archiv, T. 12, p. 100, n. 21.

"CHELIS granulatis, gracilibus, subcylindricis, carpis muticis, rostro lato, apice acuminato.

"Very similar to *C. Mexicanus*. Thorax punctulated; cretæ visible, a little divergent behind; rostrum nearly flat, broad, sharply notched on each side in front. Lamina of the antennæ very broad, nearly truncated before in front, with a little apical external spine. Hands shorter, narrow, nearly cylindrical, delicately scabrous; fingers slender; carpus scabrous, with sharp spines on the inner side; postabdomen nearly as broad as the thorax. The third pair of legs in the male hooked. Long. corp. 2.3 inch. Cuba." — Erichson.

I have not seen any species or specimen from Cuba. Perhaps this species belongs to the first group. The words in Erichson's description, literally "rostrum on each side notched in a sharp spine," translated by me "sharply notched," are doubtful. *C. consobrinus* Saussure, from the same locality, has the rostrum with anteapical spines. I know nothing more about these two species.

C. consobrinus Saussure, Revue et Magas. Zool., T. 9, p. 101, and Mém. Soc. Phys. Genève, T. 14, Pl. II. fig. 21, p. 458, from the marshes in the interior parts of Cuba, cannot be separated from *C. Cubensis* by the description. Apparently Mr. DeSaussure has seen the two forms of the male; this supposition would explain his remarks concerning the differences in the hands. But not having seen any specimens from Cuba, I am unable to give a definite judgment.

31. CAMBARUS ADVENA *Le Conte*.*Astacus advena* LeConte, Proc. Acad. Philad., T. 7, p. 402.

Figures on Pl. I., III., and VII.

First abdominal legs of the male :

first form, fig. 90 in front; fig. 91 augmented; fig. 92 outside.

Antennal lamina, fig. 164, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

Pl. VII. Male, first form.

MAS. Rostro lato, paululum longiori, fere triangulari, apice subito acuminato breviori; supra excavato, sparsim punctato, basi foveola latiori; marginibus obliquis, ad acuminis apicem non interruptis; cretis vix separatis, parum elevatis, extus obsolete sulcatis, antice obtusis, postice subdivergentibus. Antennis thorace paulo brevioribus, articulis duobus basalibus dente nullo; antennis internis articulo basali dente infero acuto medio; lamina brevi, rostri longitudine, angusta, margine externo inflato, spina apicali acuta; margine cephalothoracis angulo oculari nullo. Epistomate latiori, margine antico recto, spina media parva lateribus obliquis; pedibus maxillaribus externis intus longe barbatis. Thorace angusto, compresso-cylindrico, lævi, parce sed profunde punctato, lateribus granulis rarioribus; linea profunda, sinuata, lateribus fissa, spina antica infera ad antennarum basin; areola profunda, media fere nulla, lineari, antice posticeque profunda, triangulari, dilatata. Postabdomine angusto, lævi, lateribus parallelis, segmentis antepenultimis angulis externis subrotundatis; lamina media antice utrinque bispina, parte apicali breviori, rotundata, lamina laterali costa media usque ad marginem integra, spina marginali. Pedibus anticis modice longis validis; chela lata, inflata, parce punctata, margine externo obsolete dentato; margine interno longo, incurvo, subtus paulo sulcato, fortiter et acute serrato-dentato; margine externo obsolete dentato digitis vix longioribus, validis rectis, costatis, intus dentatis, digito mobili basi extus tuberculato. Carpo lato, oblique truncato, intus tuberculato, spina interna, subantica majori; alia minori basali (in adultis spinis nonnullis minoribus internis); subtus spinis duabus anticis obtusis; brachio modice longo, oculos superanti, lævi, margine supero tuberculato, spinis duabus anteapicalibus oblique positus acutis; subtus biserialim spinoso; pedibus tertiis articulo tertio unguiculato; pedibus quartis capitulo basali nullo. Pedibus abdominalibus longis, gracilibus, contortis, parte interna cylindrica recta, apice acuta, longiori, extus curva; parte externa sublongiori, apice dentibus duobus fusco corneis incurvis coadunatis, lamina compressa ovali, externa recurva.

Femina differt, chelis antennisque brevioribus, abdomine lato, basi thorace fere latiori; ventre inter pedes quartos lævi; annulo transversali lumine profundo, obcordiformi.

Long. corp. 2.2 ad 2.9; antenn. 1.4; ped. antic. 1.7 ad 2.

Habitat: Charleston, S. C.; Georgia; Mobile, Ala.

I have seen male and female.

This species is remarkable for the lateral lamina of the postabdomen. In the allied species the middle rib terminates in a spine before the margin; in this species the rib ends exactly on the margin, and the spine is acute and marginal.

I have compared a female type in the Philadelphia Museum. This is the largest specimen I have seen.

It differs from the *C. Carolinus* in the short and anteriorly dilated lamina of the antennæ, with a short external spine; in the teeth of the first joint of the interior antennæ, in the anterior spine at the end of the thoracic line. In the larger specimens the hand is more sulcated beneath at the inner margin, and the carpus more spinulose.

I have seen many young specimens, but only one very young male of the second form. The abdominal legs are in their first stage of development. The tip is cylindrical, simple, and a little incurved.

Cat. No. 282, Georgia, Dr. Jones. Male. Fem. Spec. 6.

32. CAMBARUS CAROLINUS *Erichson*.

Cambarus Carolinus Erichson, Wiegman. Arch., T. 12, p. 96, n. 16.

Figures on Pl. I. and III.

First abdominal legs of the male:

first form, fig. 51 in front; fig. 52 outside.

second form, fig. 53 in front; fig. 54 outside.

Antennal lamina, fig. 165, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Rostro longiori, lato, triangulari, antice deflexo, excavato, parce punctato, serie punctorum marginali, marginibus elevatis ad acuminis acuti apicem non interruptis; cretis parvis, sulcatis, antice muticis, subdivergentibus, postice callosis, convergentibus. Antennis gracilibus, thorace paulo longioribus, dentibus articularum basaliis nullis; lamina parva, angusta, margine externo inflato, spina apicali longiori. Epistomate lato, antice obtuso triangulari, lateribus obliquis, subsinuatis; pedibus maxillaribus externis intus barbatis. Thorace compresso, supra subdepresso, sparsim sed profunde punctato, lateribus granulosus; linea profunda, sinuata, lateribus fissa, spina antica infera nulla; areola angusta, plana, media subnulla, lineari, postice triangulari majori punctata. Postabdomine angusto, thorace sublongiori, parce punctato; segmentis antepenultimis angulis lateralibus rotundatis; lamina media utrinque bispina, parte apicali breviori, rotundata. Pedibus anticis brevibus, latis, chela brevi, lata, subinflata, paulo lanuginosa, punctata; margine interno curvato, serrato dentato, subtus sulcato; margine externo obsolete dentato; digitis fere æqualibus, validis, nec longioribus, rectis, costatis, lineato-punctatis, intus tuberculato-dentatis; digito mobili basi extus tuberculato. Carpo lato, oblique truncato, parce punc-

tato; latere interno tuberculato-spinoso, spina media majori; subtus spinis duabus anticis modicis. Brachio brevi, margine supero spinoso, spinis duabus anticis oblique positis majoribus; subtus biseriatim spinoso. Pedibus tertiis articulo tertio unguiculato; pedibus quartis capitulo basali orbiculari. Pedibus abdominalibus gracilibus, rectis, parte interna angustiori cylindrica, apice acuta elongata; parte externa apice subinflata, dente fusco-corneo, extus striato, triangulari, compresso, acuminato.

Forma II. Pedibus abdominalibus basi non articulatis, parte interna apice crassiori, breviori; parte externa apice magis inflata, brevi, conica, subacuta, nec fusco-cornea.

Femina abdomine vix latiori, ventre inter pedes quartos nudo; anulo fere orbiculari, antice subbituberculato, lumine centrali.

Long. corp. 2.1; antenn. 1.3; ped. antic. 1.4.

Habitat: Georgia; Carolina (Erichson).

I have seen twenty specimens; the males are younger, the male Forma II. is very young; its abdominal legs are not articulated, nevertheless it has the shape commonly observed in the second form.

This species is similar to *C. advena*, but differs as follows: the rostrum is more triangular, the thorax strongly punctulated, the areola not impressed; the apical part of the median lamina is longer, the rib in the lateral lamina ends before the margin; there are no spines at the basal joints of the smaller antennæ; the carpus beneath and on the inside has numerous spines; the lateral margins of the postabdomen are not straight, but every segment is more rounded on the outside; the sexual parts differ visibly.

I think this species is the *C. Carolinus* Erich. The description seems to agree very well; the obviously small postabdomen, the more pointed lamina of the antennæ, and the linear areola are the chief characters mentioned by Erichson. The subsequent addition, that the males have only the third pair of legs hooked, places the *C. Carolinus* without doubt in this group. All the other species of the group, except *C. obesus*, are immediately seen to differ in having a larger areola, but the enlarged postabdomen separates them from the species described by Erichson.

Cat. No. 232, Charleston, S. C., Professor L. Gibbes. Male. Fem. Spec. 2.

Cat. No. 1850, Georgia. Male. Spec. 1.

Cat. No. 230, Mobile, Ala., Mr. Forbes. Male. Fem. Spec. 12.*

Cat. No. 275, Mobile, Ala., L. Agassiz. Male. Spec. 1.

Dry Spec., Georgia, L. Agassiz. Male. Spec. 1.

ASTACUS.

Corpore robusto ; pedibus quintis branchiis gerentibus ; antennis internis flagello breviori, inæquali ; aure conico postice aperto ; pedibus maris tertius et quartis inermibus ; pedibus abdominalibus maris simplicibus ; femina annulo ventrali solido.

Having already given the differences of the genera *Astacus* and *Cambarus*, I need not here repeat them.

In its general form the species of *Astacus* are clumsy and oval. The fifth pair of legs has a gill, but without the broad, deeply folded membrane peculiar to the gills of all the other legs, which possess also a basal external bundle of shorter and irregularly placed gill-tubes. The inner antennæ are short, their bases thick, the joints more spherical and calcareous. The exterior antennæ are shorter than the body ; their lamina is prismatic, being more thickened on the external border. The epistoma is solid, conical, a little contracted in front of the tip. The ear forms an elevated cone, rounded at the top, with a narrower circular tympanum behind. The areola is broad and slightly marked. The postabdomen is always broad, the exterior angles of the segments are often elongated and acuminate. The third and the fourth pair of legs in the males never differ from the other legs, and are never hooked. The first abdominal legs in the male form a corneous, not articulated limb, with the apical half dilated and rolled from the outside inward, forming also a channel. The shape of these legs seems not to vary in the different species, at least no difference is as yet known. In the second pair of abdominal legs the inner flagellum with the dilated basal half is rolled from the inside outward, or it has exactly the form of that of the first abdominal legs, as in the European species, or it is of a more triangular shape, similar to the *Cambarus*, as in the American species. The separated and perforated annulus ventralis behind the fourth pair of legs of the females, described in *Cambarus*, is not to be found in *Astacus*. In fact, the same part exists here, though in the European species it is never separated, but forms only a slender transverse ridge, which in the American species is curved behind like a horseshoe. In the American species it is far more dilated behind in a triangular manner, excavated beneath, and apparently more similar to *Cambarus*, but neither separated nor perforated. As yet no dimorphism of the males is known, and nothing of burrowing habits in the species. It seems striking, as already mentioned, that the species of *Astacus*, especially those from Europe, offer so many varieties, which are rarely found, considering the great number of species in the American *Cambarus*. At the same time I expressly remark, that none of the characters set forth as variable in the European species is used by me to characterize and to separate the American species.

Concerning the further division of the genus *Astacus* into groups, I am not able to give a final judgment, being entirely ignorant of the Australian species, and having before me of the Amur species but one female, and of the European species only *Astacus fluviatilis*.

The European species, or more precisely *Astacus fluviatilis*, differ from all the others in having the apical part of the intermediate lamina of the postabdomen separated from the basal half, although not so strongly as in *Cambarus*; in the American and Asiatic species this part is only more or less separated at each side, it is most so in *A. Trowbridgii*.

A. fluviatilis has a basal tooth on the exterior margin of the antennal lamina, which is never to be found in any other species. This apparently very striking character is never mentioned for *A. fluviatilis*.

The Asiatic species, *A. Dauricus*, differs in having a rostrum similar to that of *C. Bartonii*, the front border of the cephalothorax strongly angulated, a narrower and more elongated thorax, with a nearly straight, transverse suture and the above-mentioned form of the annulus ventralis.

The American species are divided according to the following characters:—

I. Margins of the rostrum denticulated; front border of the cephalothorax slightly angulated.

1. Rostrum not notched in front of the tip; cretæ visible; hands barbated: *A. Gambelii*.

2. Rostrum strongly notched before the tip; no cretæ, but two spines on each side; hands without beard: *A. nigrescens*.

II. Margins of the rostrum not denticulated; front border of the cephalothorax straight.

1. Rostrum long, margins parallel, strongly notched in front of the tip: *A. Trowbridgii*.

2. Rostrum short, tapering, slightly notched before the tip: *A. Klamathensis*.

I have not seen *A. leniusculus*, which differs from both the preceding species in the acute angles of the segments of the postabdomen.

My knowledge is too limited and fragmentary to authorize my saying more respecting the geographical distribution of the species.

1. ASTACUS GAMBELII Girard.

Cambarus Gambelii Gir., Proc. Acad. N. S. Philad., T. 6, p. 90; p. 375; p. 380. — Stimpson, Proc. Boston Soc. N. H., T. 6, p. 87 (separat. p. 52).

Figures on Pl. I, III, and XI.

First abdominal leg of the male:

first form, fig. 97 in front; fig. 98 outside.

Antennal lamina, fig. 170, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

Pl. XI. Male type from California.

MAS. Pallidus obesus, rostro modico triangulari, subplano, medio

calloso-carinato, marginibus subcallosis 10-dentatis, acumine parvo, acuto, recurvo; cretis brevibus, impressis, antice subacutis. Antennis modicis (apex deest); articulis duobus basalibus dente externo brevi acuto; antennis internis articulo basali dente infero anteapicali acuto; lamina valida trigona, rostri sublongiori, angusta, margine externo sinuato, crasso, apice spina acuta breviori. Epistomate parvo, acute triangulari; pedibus maxillaribus externis intus barbatis. Thorace ovato, depresso, parce punctato, læviori; linea sinuata, modice profunda; areola lata. Postabdomine thorace non latiori, lævi, segmentorum angulis externis subacutis; lamina media parte basali quadrangulari apice utrinque bispina; parte apicali breviori, rotundata, margine apicali rotundato integro (mas alter parte basali apice angustiori, utrinque unispinoso; parte apicali brevi rotundata, margine medio exciso); lamina laterali costata. Pedibus anticis validis, longis, spinulosis; chela magna, elongata, subplana, marginibus subacutis, rectis; supra ad marginem internum et externum sulcata ac densius barbata; digitis validis, rectis, conicis, chela non-longioribus. Carpo lato, truncato, intus scabro; subtus spina media antica parva. Brachio supra ante apicem spinuloso, subtus biseriatim spinuloso, spinis ad articulationem obsoletis. Pedibus abdominalibus brevibus, rectis, dimidio apicali circumvolutis, apice truncatis.

Long. corp. 3.2"; ped. antic. 3".

Habitat: California.

I have seen two males taken by the late Dr. Gambel in California, and communicated by the Academy of Philadelphia; these same males were examined at an earlier day by Professor L. Agassiz (Proc. Acad. Philad., T. 6, p. 375).

This species is very remarkable in having tufts of fine erect hair on each side of the hands, giving to the species a very peculiar aspect. The triangular rostrum with dentated margins and the acumen only represented by a similar, but little stronger tooth, instantly separate *A. Gambelii* from the other Western species. In the second pair of abdominal legs the palpus of the penultimate joint is not longer than the leg, though this palpus in *A. nigrescens* is much longer.

Mr. Girard, l. c. p. 91, says: "Anterior pair of abdominal legs elongated resembling somewhat in shape those of *C. robustus*, to which it bears a close relationship." But the type of *C. robustus* in the Philadelphia Academy is very near *C. Bartonii*, while its abdominal legs are very different. Also *C. robustus* possesses no gills on the fifth pair of legs, and is quite unlike *A. Gambelii*.

Of the two males seen by me, one has the intermediate lamina of the postabdomen rounded at the tip, the other strongly and regularly notched. I regard the last as an accidental variety.

2. *ASTACUS NIGRESCENS* *Stimpson*.

Astacus nigrescens Stimpson, Proc. Boston Soc. N. H., T. 6, p. 87 (Separat p. 52).

Figures on Pl. III.

Antennal lamina, fig. 168, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

MAS. Obesus, obscure olivaceus; rostro longo, valido, basi latiori, antice fere parallelo, acumine triangulari, longiori acuto, subrecurvo; supra medio canaliculato basi callo obsoleto in fovea antice angulata; marginibus calloso-inflatis, sex vel octo-dentatis; loco cretarum dentibus utrinque tribus acutis. Antennis validis, corpore brevioribus, articulis duobus basalibus dente externo acuto; antennis internis articulo basali dente infero anteapicali acuto; lamina valida trigona, rostri longitudine, modice lata, margine externo crasso, inflato, apice spina longa acuta. Epistomate lato, subtus carinato, antice triangulari; pedibus maxillaribus externis subtus spinulosis, intus barbatis. Thorace ovato, depresso, densius et fortiter punctato, lateribus granulosus; linea lata profunda, utrinque subsinuata; areola lata, plana, antice latius dilatata. Postabdomine lato, fere lævi, segmentorum angulis externis elongatis acutis; lamina media parte basali quadrangulari; apice utrinque spinis duabus validis, subrejectis; parte apicali minori, angustiori, elliptica, margine antico exciso; lamina laterali vix costata, spina media antemarginali, externaque marginali. Pedibus anticis validis, longis, corpore paulo brevioribus; chela magna, elongata, subplana, marginibus subacutis, densius punctata, margine interno fere recto, subtus paulo depresso; digitis validis, rectis, chelæ longitudine, conicis, apice spinulosis. Carpo lato, granuloso, antice truncato, subtus spina media valida. Brachio lævi, margine antico et superiori spinoso, spina apicali majori, subtus biseriatim spinuloso, spina antica aliaque utrinque ad articulationem majoribus. Pedibus abdominalibus, brevibus, rectis, dimidio apicali cylindrico circumvolutis, apice truncatis.

Femina differt ventre inter pedes quartos lævi, canaliculato; annulo bifido laminato.

(Maxim.) Long. corp. 4.6; antenn. 3; ped. antic. 4.2.

Habitat: San Francisco, California.

I have seen eight males and one female; the fifth pair of legs has branchiæ. Male and female type communicated by Professor Stimpson.

This species and *A. Gambelii* are separated from the others by the denticulated rostrum.

Cat. No. 228, San Francisco, Cal., Mr. T. G. Cary. Male. Spec. 4.

Cat. No. 1851, California, Mr. T. G. Cary. Male. Spec. 1.

3. *ASTACUS TROWBRIDGII Stimpson.*

Astacus Trowbridgii Stimpson, Proc. Boston Soc. N. H., T. 6, p. 87 (Separat. p. 53).

Figures on Pl. III. and X.

Antennal lamina, fig. 171, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

Pl. X. Female type.

FEM. Obesa, olivacea, chelis obscurioribus; rostro lato longo, excavato, parce punctato, medio obsolete canaliculato, lateribus parallelis, marginatis, crassioribus; acumine triangulari, longo, angusto, acuto, fusco-corneo, spinis lateralibus validis; cretis brevioribus, antice spina rejecta; aliaque ad basin cretæ spina. Antennis corpore brevioribus modicis, articulis duobus basalibus dente externo valido; antennis internis articulo basali dente infero apicali, lamina valida, trigona rostro breviori, modice lata, margine externo crasso, apice spina longa, acuta. Epistomate triangulari; pedibus maxillaribus externis intus barbatis. Thorace ovato, antice angustiori, densius punctato, lateribus sublævibus; linea profunda, sinuata; areola lata. Postabdomine thorace latiori, apicem versus decrescente, lævi, angulis segmentorum externis rotundatis; lamina intermedia quadrangulari, apice, angustiori, utrinque spinis duabus validis, rejectis; parte apicali breviori, fere orbiculari; lamina laterali vix costata, spina media antemarginali, externaque marginali. Pedibus anticis validis, longis, corpore brevioribus; chela magna, lata, punctata subplana, marginibus subacutis, margine interdum recto subtus excavato; digitis validis, subsinuatis, chela paulo longioribus, apice spinulosis; digito mobili intus basi exciso; externo digito basi intus producto; utroque intus dentato. Carpo lato, truncato, punctato, spina antica interna acuta; subtus spina media antica. Brachio, sublævi, margine antico et superiori spinoso, spina anteapicali majori; subtus biseriatim forte spinoso, utrinque ad articulationem spina valida. Ventre inter pedes quartos lævi; annulo transverso, cylindrico.

Long. corp. 4; antenn. 3; ped. antic. 3.

Habitat: Astoria, Oregon; "near Astoria it occurs sometimes abundantly in brackish water."

I have seen two female types of Mr. Stimpson's, communicated by the Museum of the Soc. Nat. Hist. in Boston.

This species differs from *A. nigrescens* in the broad, rounded lateral angles of the abdominal segments.

4. *ASTACUS KLAMATHENSIS Stimpson.*

Astacus Klamathensis Stimpson, Proc. Bost. Soc. N. H., T. 6, p. 87 (Separat. p. 52). — Bate Spence. Naturalist in Vancouver's Island and Brit. America, 1866, T. 2, p. 278.

Figures on Pl. III.

Antennal lamina, fig. 169, *a*; epistoma, *b*; spine of the second joint of the exterior antenna, *c*.

FEM. Rostro longo, densius punctato, subplano, medio obsolete

canaliculato, antice angustiori, utrinque marginato, acumine modico, acuto, spinis lateralibus parvis; cretis brevioribus, spina antica perparva, postica nulla. Antennis corpore brevioribus (apex deest) articulo primo dente valido, secundo subnullo; antennis internis articulo basali dente infero subapicali, lamina valida, trigona, rostro breviori, lata, margine externo crasso, apice spina brevi, acuta. Epistomate triangulari; pedibus maxillaribus externis intus barbatis. Thorace ovato, antice angustiori, densius punctato, lateribus granulosus; linea profunda, sinuata; areola lata. Postabdomine thorace latiori, apicem versus decrescente, lævi, angulis segmentorum externis rotundatis, lamina intermedia quadrangulari, apice subangustiori, utrinque spinis duabus validis rejectis; parte apicali breviori, rotundato; lamina laterali vix costata. Pedibus anticis modicis, brevibus; chela modica, punctata, subplana, marginibus subacutis, margine interno recto, subtus excavato; digitis validis, subrectis, chelæ non longioribus, apice spinulosus, non dentatis. Carpo lato, truncato, punctato, intus mutico; subtus spina media antica parva. Brachio sublævi, spina anteapicali majori, subtus biserialiter spinoso, utrinque ad articulationem spina interna valida. Ventre inter pedes quartos lævi, annulo transverso, cylindrico, bipartito.

Long. corp. 3"; ped. antic. 2.1".

Habitat: Klamath Lake, California; in all streams east of the Cascades. Sp. Bates.

I have seen only one female type, in bad condition, communicated by Dr. W. Stimpson.

It may be distinguished from *A. Trowbridgii* by its stronger and more punctulated thorax, its tapering rostrum, with less developed spines, the shortly spined antennal lamina, the smaller hands, the carpus without internal apical spine; the annulus between the fourth pair of legs divided in the middle.

The accurate determination of this species requires the examination of more specimens; the antennal lamina on the right side is accidentally abnormal, perhaps the other is also a little changed in shape.

5. *ASTACUS LENIUSCULUS* Dana.

Astacus leniusculus Dana, Proc. Acad. N. H. Philad., T. 6, p. 20. — U. S. Exploring Exped. Crustac., T. 1, p. 524, t. 33, fig. 1. — Stimpson, Proc. Boston Soc. N. H., T. 6, p. 87.

"Rostrum tridentatum, dentibus acutis, medio tenuiter elongato. Carapax lævis, punctulatus, lateraliter pone rostrum utrinque bispinosus; areola inter suturas longitudinales postdorsales lata. Pedes antici compressi, inermes, non tuberculati, manu lævi, punctulata, carpo paulo oblongo, intus recto, inermi, apice interno acuto excepto; brachio antice denticulato, apice interno elongate acuto, dorso unispinoso. Pedes sequentes nudiusculi. Segmentum caudale parce oblongum, lateribus

fere parallelis. Pedes 5^a branchias parvas gerentes. Hab. flumine Columbiae," Oregoniæ. Long. 4". — *Dana*.

In the description Mr. Dana says, "arm with anterior margin denticulate, and a longer tooth at apex, on *outer* margin, short distance from apex, unispinous."

"May be recognized by its well-developed thoracic spines, and light color. Has a general resemblance to *A. Trowbridgii*; differs from that species in having more prominent thoracic spines; the rostrum is somewhat shorter and broader, the dorsal area broader." — *Stimpson*.

Habitat: Columbia River; Puget Sound.

I have not seen this species, which seems to be very similar to *A. nigrescens*, except in the non-denticulated margin of the rostrum. The description and the figure given by Mr. Dana are not sufficient.

6. ASTACUS OREGANUS *Randall*.

Astacus Oreganus Randall, Journ. Acad. N. S. Philad., T. 8, Pl. I., p. 138, t. 7. — Erichson, Wieg. Arch., T. 12, p. 375. — Girard, Proc. Acad. N. S. Philad., T. 6, p. 87. — Stimpson, Proc. Boston Soc. N. H., T. 6, p. 87 (Separat. p. 55).

"Body fuscous, granulated, carpus with a sharp spine at the interior angle; arm produced into a spine on each side anteriorly; thorax behind the front with five spines, placed three before and one on each side behind the lateral ones; a large reddish spot on each side posteriorly; front little reflected on the sides, terminating in a very long, slender spine, and having a short, marginal spine on each side. Long. 4". Columbia River.

"Testa granulata, bimaculata, fronte valde producta." — *Randall*.

Erichson, in his translation of this description, makes a mistake, "das Magenfeld an jeder Seite mit fuenf Dornen, naemlich drei vor und zwei hinter den Seitendornen"; Randall by no means says that there are five spines on each side.

"Dr. Randall's single specimen of this species was unfortunately lost by the artist employed in delineating it. No other example has been since found, although its locality has been since repeatedly searched. If the figure in the eighth volume, etc., is correct, this is a very remarkable species, differing from all others known, in possessing a median thoracic spine as well as in the length of the terminal rostral tooth, and above all in the singular lateral appendages of the abdominal segments." — *Stimpson*.

The figure published by Randall is without doubt very incorrect, giving one segment too much in the postabdomen, and a little claw at the tips of the fourth pair of legs. The curious lateral appendages to the segments of the postabdomen are probably its lateral angles, acute as in *A. nigrescens*, or the artificially protruded abdominal legs. Mr. Ran-

dall would have mentioned these very curious organs in his description if they had really existed. The tail is apparently very poorly figured, but the strong spines at the apex of the intermediate lamina are directed outward as well as in the lateral lamina and the base in the same manner as in *A. nigrescens* and *Trowbridgii*. I think the spine in the middle of the base of the beak is not at all a spine, but merely a carinated elevation very badly figured. *A. nigrescens* has a similar but not so well produced elevation; the spines could not have been very prominent, as the painter did not figure them at all. It is possible that the form of the carpus and brachium is as badly exaggerated. The exterior antennæ are apparently too short, and the length of the rostrum, so much longer than the peduncle of the antennæ, is probably erroneous; the lamina of the antennæ is figured as *triarticulate*! I think the characters quoted make it evident that the figure is without scientific value.

It is impossible to recognize this species, from an incomplete description and a very inadequate figure. The general appearance (although the mesothorax is very short) seems to point to a species near *A. leniusculus* and *Trowbridgii*, both being from the same locality, while the outwardly directed spines on the tail are truly characteristic of this group. The rostrum has the shape of *A. leniusculus*. The position of the five spines behind the front is very doubtful, and probably Erichson intended to give by the figure, which shows the little marks on each side, a more correct view of their position. The apparent incorrectness induces me to think that *A. Oreganus* can be no other than *A. leniusculus*, or else is to be struck out entirely.

ON THE GEOGRAPHICAL DISTRIBUTION.

The several different species mentioned have the following distribution:—

Genus **CAMBARUS**.

GROUP I.

1. **C. acutus.**

Louisiana: New Orleans, Milliken's Bend.
Alabama: Mobile.
South Carolina: Charleston, Summerville.
Missouri: St. Louis.
Mississippi: Kemper County.
Virginia: James River.

Var. **A.**

Illinois: Lawn Ridge, Basson Pudge, Evanston, Peoria, Athens.
Indiana.

Var. **B.**

North Carolina: Beaufort.
New Jersey: Essex.
New York.

2. **C. Clarkii.**

Louisiana: New Orleans.
Texas: between San Antonio and El Paso del Norte.

3. **C. troglodytes.**

South Carolina: Charleston.
Illinois: Lawn Ridge.
Georgia.

4. **C. Blandingii.**

South Carolina: Camden.

5. **C. fallax.**

Florida.

6. **C. Lecontei.**

Alabama: Mobile.
Florida: Pensacola.
North Carolina: Beaufort.
Georgia: Milledgeville.
Mississippi: Root Pond.

7. **C. spiculifer.**

Georgia: Athens, Roswell.

8. **C. angustatus.**

Georgia: Georgia inferior.

9. **C. versutus.**

Alabama: Mobile, Spring Hill.

10. **C. maniculatus.**

Georgia: Georgia inferior.

11. **C. penicillatus.**

South Carolina: Charleston.
Georgia.

12. **C. Wiegmanni.**

Mexico.

13. **C. pellucidus.**

Kentucky: Mammoth Cave.

GROUP II.

14. **C. lancifer.**

Mississippi: Root Pond.

15. **C. affinis.**

Pennsylvania: Delaware, near Philadelphia, Pittsburg, Carlisle, Reading, Schuylkill River, Erie.
Maryland: Havre de Grace.
District of Columbia: Potomac at Washington.
New Jersey.
New York: Niagara.

16. **C. virilis.**

British America: Lake Winnipeg, Saskatchewan, Red River, Lake Superior, Toronto.
Illinois: Quincy.
Iowa: Davenport.
Wisconsin: Sugar River.

Var. **A.**

Iowa: Davenport, Burlington.
Missouri: Osage River.
Ohio: Dayton, Miami River.
Texas.

17. **C. placidus.**

Illinois: Quincy.
Tennessee: Lebanon.
Texas.

18. **C. juvenilis.**

Kentucky: Little Hickman, Kentucky River.
Missouri: Osage River.

19. **C. propinquus.**

Canada: Lake Superior.

C. propinquus — *Continued.*

New York : Lake Oneida, Rochester, Niagara, Grass River, Lake Ontario, Four-Mile Creek, Oswego, Garrison Creek, Sackett's Harbor.

Illinois : Ogle County.

Indiana : Delphi.

20. C. obscurus.

New York : Genessee River, Rochester.

? Virginia : (*A. fossor* Raf.)

? Pennsylvania : (*A. fossor* Raf.)

21. C. rusticus.

Ohio : Cincinnati.

Canada : Lake Superior.

22. C. immunis.

Illinois : Belleville, Lawn Ridge.

Alabama : Huntsville.

North Carolina : Beaufort.

23. C. extraneus.

Georgia : Tennessee River.

GROUP III.

24. C. Bartonii.

Canada : Lake Superior.

Vermont : in most of the small streams in the western part of the State.

New York : Lake Champlain, Elizabethtown, Berkshire, Fishkill, Newburg, Western New York.

New Jersey : Schooley's Mountain.

Pennsylvania : Philadelphia, Schuylkill River, Berwick, Hammetstown.

Ohio : Cincinnati, Sciota River, Columbia.

Kentucky : Hickmann's Landing, Kentucky River, Mammoth Cave.

District of Columbia : Georgetown.

C. Bartonii — *Continued.*

Missouri : Osage River.

Virginia : Greenbrier River.

25. C. robustus.

Canada : Toronto, Humber River.

New York : Genessee River, Rochester, Lake Regis, Adirondack Region.

Virginia : Fredericksburg.

26. C. obesus.

Illinois : Prairie near Chicago, Evanston, Lawn Ridge.

Missouri : Belleville.

Ohio : Kelley Island, Lake Erie.

New York : Garrison Creek, Sackett's Harbor, Lake Ontario.

Arkansas.

Virginia : Petersburg.

Mississippi : Monticello.

Louisiana : New Orleans.

27. C. Nebrascensis.

Nebraska.

28. C. latimanus.

Georgia : Athens.

South Carolina.

29. C. Mexicanus.

Mexico.

30. C. Cubensis.

Cuba.

31. C. advena.

Georgia.

South Carolina : Charleston.

Alabama : Mobile.

32. C. Carolinus.

Georgia.

Carolina (or South Carolina?).

Genus **ASTACUS.****33 (1). A. Gambelii.**

California.

34 (2). A. nigrescens.

California : San Francisco.

35 (3). A. Trowbridgii.

Oregon : Astoria.

36 (4). A. Klamathensis.

Oregon : Lake Klameth, Cascades.

A. Klamathensis — *Continued.*

British Columbia : all streams east of the Cascades.

37 (5). A. leniusculus.

Oregon : Columbia River.

Washington Territory : Puget Sound.

38 (6). A. Oreganus.

Oregon : Columbia River.

DISTRIBUTION OF THE SPECIES OF CAMBARUS

IN EVERY STATE OR TERRITORY ACCORDING TO LOCALITIES YET ASCERTAINED.

1. MAINE. — None.
2. NEW HAMPSHIRE. — None.
3. VERMONT. — *C. Bartonii*, Burlington, Shelburne, Colchester, Chittenden County, in affluents of Lake Champlain.
4. MASSACHUSETTS. — None. I am told by Mr. S. H. Scudder that fresh-water crabs (*C. Bartonii*) have been collected in the western parts, at Williamstown. Lewis R. Gibbes cites, on the authority of Dr. Gould, *C. Bartonii* from Massachusetts.
5. CONNECTICUT. — None.
6. RHODE ISLAND. — None.
7. NEW YORK. — Seven species: *C. acutus* var. B., *C. affinis*, *C. propinquus*, *C. obscurus*, *C. Bartonii*, *C. robustus*, *C. obesus*.

C. Bartonii lives in the western part of the State, on the Hudson River and its affluents; in the southern, at Newburg and Fishkill; in the northeastern, along Lake Champlain, and particularly at Elizabethtown, Essex County; also in the Tioga affluent of the Susquehanna at Berkshire, Tioga County. Rafinesque also mentions Lake George, Saratoga, Utica, and Oswego, but perhaps the latter locality belongs to *C. propinquus*.

C. propinquus lives in the northern part of the State, in Lake Ontario, in its affluents, the Genesee River at Rochester, Garrison Creek near Oswego, Lake Oneida, Four-Mile Creek near Sackett's Harbor, and in Grass River, a branch of the St. Lawrence River.

C. obscurus and *C. robustus* also live in the Genesee River at Rochester, *C. obesus* lives in Garrison Creek.

C. affinis lives in the western part, at Niagara. For *C. acutus* the locality is not given.

Our knowledge of the great State of New York is mostly confined to the northern and the western border. The remainder, with the exception of a small portion of the southern limits, is unknown.

8. NEW JERSEY. — Three species: *C. acutus* var. B., *C. affinis*, *C. Bartonii*.

The first species is from Essex; of the second the locality is not given; the third is from Schooley's Mountain, Morris.

Of the State of New Jersey our knowledge is limited to two points in two counties very near New York, and to the rivers which empty into the outlet of the Hudson River.

9. DELAWARE. — None.

10. PENNSYLVANIA.—Three species: *C. affinis*, *C. obscurus* (?), *C. Bartonii*.

The first and the third species are known from the Delaware River (Philadelphia) and from the Schuylkill River (Carlisle, Reading), from the Susquehanna and its affluents (Hummelstown, Berwick), and from the Ohio (Pittsburg). *C. obscurus* (if it be the *A. fossor* Raf.) is from Philadelphia.

In the great State of Pennsylvania, which consists of sixty-five counties, we are acquainted with only a few single localities in six counties. Of these, one is on the eastern border, another on the western, while the four others lie near together in the middle of the State.

11. MARYLAND.—One species: *C. affinis*.

Only one locality, Havre de Grace, at the mouth of the Susquehanna, is known.

12. VIRGINIA.—Five species: *C. acutus*, *C. Bartonii*, *C. robustus*, *C. obesus*, and *C. obscurus* (if it is the *A. fossor* Raf.).

Out of one hundred and sixty-five counties our knowledge extends to only four, — the James River and its affluents, at Petersburg, the Rappahannock (Fredericksburg), and Greenbrier River in the western part.

13. DISTRICT OF COLUMBIA.—One species: *C. Bartonii*, at Georgetown.

14. NORTH CAROLINA.—Three species: *C. acutus* var. B., *C. Lecontei*, *C. immunis*; all from Beaufort, on the southeastern border.

15. SOUTH CAROLINA.—Seven species: *C. acutus*, *C. troglodytes*, *C. Blandingii*, *C. penicillatus*, *C. latimanus*, *C. advena*, *C. Carolinus*.

C. Blandingii is from the northern border, Wateree River; all the others are from Charleston and Summerville, on the southern border.

16. GEORGIA.—Ten species: *C. troglodytes*, *C. Lecontei*, *C. spiculifer*, *C. angustatus*, *C. maniculatus*, *C. penicillatus*, *C. extraneus*, *C. latimanus*, *C. advena*, *C. Carolinus*.

Georgia, thanks to the monograph of Mr. John LeConte, is as yet still the best explored State. He describes nine species; one, *C. fossarum*, is perhaps identical with *C. troglodytes*. *A. Blandingii* I have not been able to determine with certainty. Two other species have been seen by him, making in all ten species, exactly the number I have marked. It is a pity that he never gives the exact localities. *C. spiculifer*, *C. latimanus* are noticed as living “in Georgia superiore”; *C. troglodytes*, *C. fossarum*, *C. maniculatus*, *C. angustatus*, *C. advena*, “in Georgia inferiore”; *C. Blandingii*, “in regionibus intermediis.”

Our knowledge of localities enables us to credit *C. spiculifer* and *C. latimanus* to Athens, *C. Lecontei* to Milledgeville, and *C. spiculifer* to Roswell; also to two points in the northern parts and to one in the middle of the State. *C. extraneus* is cited from the Tennessee River, Georgia, but this river does not touch the limits of Georgia.

17. FLORIDA. — Two species: *C. fallax* and *C. Lecontei*.

The only locality given is Pensacola, on the northwestern border, near Alabama. Our knowledge of Florida also is very scanty. Lewis R. Gibbes quotes *C. affinis* from Florida, but his determinations are not at all trustworthy.

18. ALABAMA. — Five species: *C. acutus*, *C. Lecontei*, *C. versutus*, *C. immunis*, *C. advena*.

C. immunis lives in Huntsville, on the northern border; all the other species occur at Mobile, in the southwestern limits of the State. Nearly the whole State remains unexplored.

19. MISSISSIPPI. — Four species: *C. acutus*, *C. obesus*, *C. Lecontei*, *C. lancifer*. The first from the Mobile River, Kemper County, the middle of the eastern border of the State; *C. obesus* from Monticello; the two others from Root Pond, a locality unknown to me.

20. LOUISIANA. — Three species: *C. acutus*, *C. Clarkii*, *C. obesus*.

The species are from the southeastern border from New Orleans, one also from the northeastern border, from Milliken's Bend; all from the Mississippi. Nearly the whole State remains to be explored.

21. TENNESSEE. — One species: *C. placidus*, from Lebanon, nearly in the middle of the State.

22. KENTUCKY. — Three species: *C. pellucidus*, *C. juvenilis*, *C. Bartonii*.

Besides the celebrated species from the Mammoth Cave, *C. pellucidus*, the others are from Little Hickman and Hickman's Landing, near the Kentucky River, in the middle of the State.

23. INDIANA. — Two species: *C. acutus*, *C. propinquus*.

Only one of the ninety-two counties gives a species; this is from Delphi, on the Wabash River, in the middle of the State.

24. OHIO. — Four species: *C. virilis*, *C. rusticus*, *C. Bartonii*, *C. obesus*.

Only in the southwestern part of the State, from Cincinnati and Columbia, and a little farther, from Dayton, Miami River, Montgomery County, are species noticed. *C. obesus* is from Kelley Island, Lake Erie. We know of species from only two of the eighty-eight counties.

25. MICHIGAN. — None. I am told that fresh-water crabs occur in Lake St. Clair; species are also noticed from Lake Superior.

26. WISCONSIN. — *C. virilis*, from the Sugar River. I am told that fresh-water crabs are found near Milwaukee.

27. MINNESOTA. — None. Professor Agassiz has found a species of *Cambarus* at Minnehaha Falls, above St. Paul. I have not seen the specimen.

28. IOWA. — One species: *C. virilis* is found in the Mississippi at Davenport and Burlington, along the southeastern border. The State is unexplored.

29. ILLINOIS. — Seven species: *C. acutus* var. A., *C. troglodytes*, *C. virilis*, *C. placidus*, *C. propinquus*, *C. immunis*, *C. obesus*.

This State is one of the best explored, for I have seen in the Museum of the Chicago Academy sixty glasses with *Cambarus*, mostly from the different localities of Illinois, but I was not able to ascertain the species. There are known from the northern border, as at Chicago and Evanston, *C. acutus* var. A., and *C. obesus*; from the middle northern parts (Illinois River and affluents), Ogle County, Lawn Ridge, Basson Pudge, Peoria, Athens, *C. acutus* var. A., *C. troglodytes*, *C. propinquus*, *C. immunis*, *C. obesus*, and from the western border from the Mississippi, from Quincy and Belleville, *C. virilis*, *C. placidus*, and *C. immunis*.

30. MISSOURI. — Five species: *C. acutus*, *C. virilis*, *C. juvenilis*, *C. Bartonii*, *C. obesus*. All are from St. Louis and from the Osage River, near the centre of the State.

31. ARKANSAS. — One species: *C. obesus*, locality unknown.

32. TEXAS. — Three species: *C. Clarkii*, *C. virilis*, *C. placidus*; the first occurs near the middle of the State, between San Antonio and El Paso del Norte; of the others the localities are unknown.

33. INDIAN TERRITORY. — None.

34. KANSAS. — None. I have seen only one species in the Chicago Museum.

35. NEBRASKA. — One species: *C. Nebrascensis*, without locality.

36. DAKOTA. — None. I have seen only one specimen in the Chicago Museum.

37. WYOMING. — None.

38. MONTANA. — None.

39. IDAHO. — None.

40. COLORADO. — None.

41. UTAH. — None.

42. ARIZONA. — None.

43. NEW MEXICO. — None.

44. NEVADA. — None.

45. WASHINGTON TERRITORY. — One species: *A. leniusculus*, at Puget Sound.

46. OREGON. — Three species: *A. Trowbridgii*, *A. leniusculus*, *A. Klamathensis*. From Astoria, from the Columbia River and Lake Klamath. The locality of *A. Oreganus* is doubtful.

47. CALIFORNIA. — Two species: *A. Gambelii* and *A. nigrescens*. From San Francisco.

BRITISH AMERICA. — Five species: *C. virilis*, *C. propinquus*, *C. Bartonii*, *C. robustus*, *C. Klamathensis*.

In Canada from the Humber River near Toronto is noticed *C. robustus*. In Lake Superior *C. Bartonii*, *C. propinquus*, *C. virilis* occur, the latter also in Lake Winnipeg, Saskatchavan, and the Red River. *A. Klamathensis* is found in British Columbia.

MEXICO. — Two species: *C. Wiegmanni*, *C. Mexicanus*. One from the marshes of the valley of Mexico, the other without known locality.

CUBA. — One species: *C. Cubensis*, from the marshes in the central part of Cuba.

According to the list given above, we know nothing upon the geographical distribution or even the existence of species in the following nineteen States and Territories: —

1. Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, Delaware, Michigan, Minnesota, Indian Territory, Kansas, Dakota, Wyoming, Montana, Idaho, Colorado, Utah, Arizona, New Mexico, Nevada.

2. From nine States and Territories we know one species, the locality being definitely known in only one half of them, viz., Vermont, Maryland, District of Columbia, Tennessee, Iowa, Arkansas, Wisconsin, Nebraska, and Washington Territory.

3. From three States we know two species, viz., Florida, Indiana, California.

4. From eight States we know three species, viz., New Jersey, Pennsylvania, North Carolina, Louisiana, Kentucky, Texas, Oregon.

5. From Ohio and Mississippi, four species.

6. From three States we know five species, viz., Virginia, Alabama, Missouri.

7. From three States we know seven species, viz., New York, Illinois, South Carolina.

8. From one State we know ten species, viz., Georgia.

The first step to take, and the best way if we would make progress in knowledge, is always to ascertain how limited it is; and for this purpose it is evidently profitable to show that the undoubtedly unrivalled materials before me represent a very limited part of the gigantic territory comprised in the United States. Besides more than the western half, noticed before as not represented in our catalogue, it is surprising that the much-explored New England States are nearly wanting. Perhaps the multitude of manufactories and the consequent spoiling of the water, especially of the running streams, has some influence on the rarity of the fresh-water crabs; but a more careful exploration is doubtless necessary to prove the existence or the absence of *Astacidae*.

At the same time some of the other States, seemingly better represented in our catalogue, are far from being well explored; even some, furnishing the largest number of species, are in reality to a great extent unexplored.

Of the great State of New York we are only acquainted with the eastern border, and in New Jersey with a single locality in the vicinity of New York City. In Maryland and the two Carolinas we know only a small area, along the eastern limits. In Florida, Alabama, and Louisiana, only the localities very near to each other are noticed, while all the rest of these States are unexplored. The number of species in

Georgia, the best explored portion of the country, suggests how much may be found in the adjacent States. The Middle States are in parts better explored, but without doubt they will furnish many new species or show a wider distribution of the known species, as is stated in our catalogue.

It would be very interesting to ascertain whether the extensive tablelands between the Sierra Nevada of California and the Rocky Mountains, as well as the great American desert, possess species of the genus *Astacus* or of the genus *Cambarus* or not. As yet nothing is known about these regions.

Perhaps under these circumstances a detailed exposition of the geographical distribution of the North American *Astacidae* would be premature and incorrect, but some facts are too striking and too apparent to be overlooked, even at this stage of our knowledge.

The first and chief point ascertained as yet is the strict limitation of the genera *Astacus* and *Cambarus*, which completely exclude each other. In the parts west of the Sierra Nevada, and perhaps of the Rocky Mountains, lives the genus *Astacus*, in all the eastern parts the genus *Cambarus*. At present no exception is known. This fact is all the more interesting, as the only species known from the eastern parts of Asia, *Astacus Dauricus* Pallas, which is probably identical with *Astacus leptorhynchus* Fisher, from the Amur River, seems to be a group intermediate between the European and North American species of *Astacus*, and more nearly related to the species of the latter country.

Our knowledge of the geographical distribution of the North American species of *Astacus* is as yet too limited for us to say anything more respecting them.

The second fact, which seems to be ascertained, is that the genus *Cambarus* is confined to the other parts of North America and perhaps to the Antilles. I have not seen the species described by Erichson and de Saussure from Cuba, but it doubtless belongs to the genus *Cambarus*. The asserted presence of the genus *Cambarus* in South America is to be discredited, unless further and more trustworthy evidence be produced in its favor. *C. Chilensis*, mentioned by Erichson as a species of *Cambarus*, was never seen by him, and seems from the description to be more nearly related to *Cheraps*, or perhaps to represent some distinct genus. I have seen one and only one specimen of *Astacidae* from Brazil, — if there be no error as to the habit, which was apparently the case with some *Astacus fluviatilis* communicated to me as Brazilian species, — a male in a very bad state of preservation, and evidently nearly related to *C. Chilensis*. As the specimen is dry and very old, it is impossible to ascertain whether it have gills or not on the fifth pair of legs.

The *C. Bartonii*, figured and described as perhaps from Brazil by Mr. Dana in his excellent work, is certainly not identical with the *C. Bar-*

tonii from North America. The habitat is uncertain, and so not of decisive value.*

Concerning the geographical distribution of the genus *Cambarus*, we find the interesting fact that the most distinct group, containing the species related to *C. acutus*, seems to be confined to a limited territory. Its boundaries answer for the most part to the Southern fauna, traced by Professor L. Agassiz for the *Chelonians*, but is somewhat more extensive, as some species are observed to live also in the upper parts of the rivers and their affluents. Beginning on the Atlantic coast in Virginia (also farther north, as with the *Chelonians*), it extends through the Carolinas, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas.

Some species follow up the Mississippi and its tributaries for a great distance, while a peculiar variety, described by me as *C. acutus* var. A, has its habitat far to the north, and is not to be found in the southern parts. It is very interesting to remark that the same species is to be found farther north on the Atlantic coast, forming also a peculiar variety, described by me as *C. acutus* var. B, from New Jersey and New York. It was impossible for me to give an adequate account of it, as I have not seen the male.

Our knowledge of the Mexican fauna is very meagre, but it seems probable that a few species at least belong to the same group. Still more interesting is the fact that some species of the other *Cambarus* groups, living within the limits noticed for the species for the first group, have an analogous appearance and shape of body, viz., *C. lancifer*, *C. immunis*, *C. extraneus*, *C. advena*, and *C. Carolinus*.

I have heretofore stated that these species, even when viewed under other relations, constitute aberrant forms. But it should be remembered that several species, viz., *C. placidus*, *C. obesus*, *C. latimanus*, which also live in the same southern country, belong in all their characters to very different groups. The groups of *Cambarus*, as defined by me, do not apparently coincide with certain faunal regions.

The species of the second group, except the aberrant forms before mentioned, especially the species related to *C. virilis*, belong to the northern and middle parts of North America. These species occur especially in the Northern Lakes and their affluents, also in the Missouri, Mississippi, Ohio, and their tributaries, and in Texas.

C. affinis, a somewhat peculiar species, alone lives in the rivers running eastward to the Atlantic coast, in the Hudson, Delaware, Potomac, Susquehanna, and their affluents.

* Von Martens, in Troschel Archiv, 1869, T. 35, p. 15 sqq., describes two species of freshwater crabs from Brazil, *Astacus pilimanus*, p. 15, Tab. 2, fig. 1, from Porto Alegre and Santa Cruz, in the affluents of the Rio Pardo River, which is an affluent of the Jacuhy River, with burrowing habits, *Astacus Brasiliensis*, p. 16, Tab. 2, fig. 2, from Porto Alegre and from Roedersberg, in ponds and small rivers. The latter is perhaps the species from Brazil mentioned by me, p. 11.

Professor H. Burmeister writes to me that he has seen a species of *Astacus* from the Banda oriental.

Evidently the faunal area of the second group of species coincides with that of the first group in the vast regions watered by the Mississippi and its branches, without touching, except in some aberrant forms, the southeastern regions.

The third group occurs in the whole country inhabited by the two others, in the Northern Lakes and their affluents, in the rivers running both to the Atlantic coast and to the Mississippi; in short, equally in the northern and southern, in the eastern and western parts of the United States. *C. Bartonii* and the next allied species are to be found in Lake Superior and in the St. Lawrence River, in Nebraska, Arkansas, Louisiana, and along the Atlantic coast from Vermont to South Carolina, and perhaps to Florida.

An interesting fact in the geographical distribution of the animals is the association or exclusion of certain species, also the representation of given species in different localities by others that are closely allied.

Concerning the association of particular species, I would remark that the materials before me give for two localities four species. I have seen from Charleston, *C. acutus*, *C. troglodytes*, *C. penicillatus*, and *C. advena*; from Mobile, *C. acutus*, *C. Lecontei*, *C. versutus*, and *C. advena*.

From six localities three species are cited: from New Orleans, *C. acutus*, *C. Clarkii*, *C. obesus*; Lawn Ridge, *C. acutus*, *C. immunis*, *C. obesus*; Beaufort, *C. acutus*, *C. Lecontei*, *C. immunis*; Lake Superior, *C. virilis*, *C. propinquus*, *C. Bartonii*; Rochester, *C. propinquus*, *C. obscurus*, *C. robustus*; Osage River, *C. virilis*, *C. juvenilis*, *C. Bartonii*.

Two species are quoted from more localities: from St. Louis, *C. acutus*, *C. obesus*; Root Pond, *C. Lecontei*, *C. lancifer*; Athens, Ga., *C. spiculifer*, *C. latimanus*; Quincy, Ill., *C. virilis*, *C. placidus*; Niagara, *C. affinis*, *C. propinquus*; Philadelphia, *C. affinis*, *C. Bartonii*; the Mammoth Cave, *C. pelulcidus*, *C. Bartonii*; Cincinnati, *C. rusticus*, *C. Bartonii*; Evanston, Ill., *C. acutus*, *C. obesus*.

The list given shows no regularity, at least I am not able to find any; still, this is perhaps because of the incompleteness of the material. Looking over the species that occur together, we find the most nearly related living with those that are evidently different; those of the first group with others of the second, some of the second with others of the third, and even all three groups in the same locality.

No more regularity is to be found in association of the different species. *C. acutus* lives in seven different localities together with eight different species, the half belonging to the other groups. *C. advena* is found in the same localities with five other species, none belonging to its own group. *C. Lecontei*, *C. obesus*, *C. virilis*, *C. Bartonii* live together with four, *C. propinquus* with five different species, partly belonging to different groups.

The uncertainty already referred to prevents my dwelling upon the

exclusion or representation of particular species. New explorations would no doubt very soon and perhaps entirely alter any views we might form from incomplete materials.

C. acutus, *C. virilis*, *C. Bartonii*, and *C. obesus* are the most widely spread species.

The geographical distribution according to the river systems is as follows:—

The rivers west of the Mississippi, running to the Gulf of Mexico, are little explored. From Texas, perhaps from the branches of the Colorado, *C. Clarkii*, *C. virilis*, and *C. placidus* are cited; the two latter were collected by Mr. Stolley, the locality not being given.

The Mississippi and its numerous well-known affluents contain a great number of species. In the lower part of this river, and in its inferior affluents, especially near its mouth, as at New Orleans, occur *C. acutus*, *C. Clarkii*, *C. obesus*; a little higher up in the branches on either side are found *C. Clarkii*, *C. Lecontei*, *C. lancifer*, *C. obesus*.

The Ohio River and its affluents furnish *C. virilis*, *C. placidus*, *C. juvenilis*, *C. rusticus*, *C. Bartonii*; while in the Wabash River, one of its lower branches, occur *C. acutus* and *C. propinquus*. The fauna of the Ohio River is also quite different from that of the Lower Mississippi, if we exclude from consideration *C. acutus* and the two species *C. virilis* and *C. placidus*, which are found in the Colorado River.

The middle part of the Mississippi, the Missouri, with the Osage River and their several branches, contain *C. acutus*, *C. obesus*, *C. Nebrascensis*, *C. placidus*, *C. virilis*, *C. juvenilis*, *C. Bartonii*; the three latter species being from the Osage River; also nearly the same species as are cited in the Ohio fauna.

In the Upper Mississippi and its affluents, especially in the Illinois River, are found *C. acutus* var. A., *C. troglodytes*, *C. virilis*, *C. placidus*, *C. propinquus*, *C. immunis*, *C. obesus*. It is worthy of remark that a channel unites the Illinois and the Chicago Rivers, and that perhaps in this way may be explained the occurrence of the southern species *C. acutus* and *C. obesus* at Evanston, on Lake Michigan. Among the several rivers and their branches lying to the east of the Mississippi, it may be added that the Mobile River contains *C. Clarkii*, *C. Lecontei*, *C. versutus*, *C. immunis*; while in the Florida rivers occur *C. Lecontei* and *C. fallax*. Two of them, *C. versutus* and *C. fallax*, are not as yet known farther to the west.

The rivers east of the Alleghany Mountains furnish in Georgia, *C. troglodytes*, *C. Lecontei*, *C. spiculifer*, *C. angustatus*, *C. maniculatus*, *C. penicillatus*, *C. extraneus*, *C. latimanus*, *C. advena*, *C. Carolinus*; also besides the first two a quite different and new fauna. Farther north, in South Carolina, live *C. acutus*, *C. troglodytes*, *C. Blandingii*, and *C. penicillatus*; in North Carolina, *C. acutus*, *C. Lecontei*, and *C. immunis*,—species which

are nearly all, except *C. Blandingii* and the Georgian *C. penicillatus*, represented at the mouth of the Mississippi.

In Virginia, in the James River and its affluents, we find *C. Bartonii* and *C. robustus*, with the southern form *C. acutus*. The first-named species descends no farther than to the middle of the Mississippi; the second is of a decidedly northeastern type, more properly belonging to the fauna characteristic of the waters that empty into the St. Lawrence. In the more northern rivers, especially in the Potomac, Susquehanna, Delaware, and their tributaries, we find *C. Bartonii* and *C. affinis*, and perhaps *C. obscurus*.

In the Hudson River, also in the other streams as far north as Vermont, and in Lake Champlain, occurs *C. Bartonii*. But the mouth of the Hudson River in New Jersey and New York is the extreme limit of a peculiar variety of the southern species *C. acutus*, which is well represented in North Carolina.

The fauna east of the Alleghany Mountains is also very peculiar. Perhaps the most peculiar part is the well-explored and striking fauna of Georgia. But we find farther to the north—besides *C. acutus*, widely extended in the South, and *C. Bartonii*, a species to be found in the whole middle part of the United States,—the exclusively northeastern species *C. affinis* and *C. obscurus*.

The northern fauna, comprised in the immense water-basin of the St. Lawrence and its tributaries, furnishes in Lake Superior, *C. virilis*, *C. propinquus*, *C. rusticus*, *C. Bartonii*; in the Niagara, *C. affinis* and *C. propinquus*; in Lake Ontario and its affluents, especially Genesee River and Lake Oneida, *C. propinquus*, *C. obscurus*, *C. Bartonii*, *C. robustus*, *C. obesus*. Some of these species, and in fact all those found in Lake Superior, as *C. virilis*, *C. propinquus*, *C. rusticus*, *C. Bartonii*, *C. obesus*, are also represented in the regions watered by the Upper Mississippi and its branches; *C. obscurus*, *C. affinis*, and *C. robustus* are the only species peculiar to the northern fauna. The remarkable habitat of *C. acutus* and *C. obesus* in Lake Michigan has been before mentioned.

C. virilis occurs in the more northern waters, which empty into Hudson's Bay, especially in Lake Winnipeg, Saskatchawan, and Red River. I am told that these waters are connected in the summer time through marshes with the affluents of the Upper Mississippi.

We also find true, especially for the genus *Cambarus*, that the United States are divided into three great faunal regions,—the region traversed by the Mississippi; the eastern region, lying between the Alleghany Mountains and the Atlantic coast; and the northern region, which is watered by the Northern Lakes and the St. Lawrence. I have not spoken of the Mexican and Cuban species, my acquaintance with them being as yet very imperfect.

The three great regions just mentioned, particularly the first and the

second, doubtless comprise several subordinate faunal districts. The region watered by the Mississippi apparently divides itself into two parts, a southern and a northern, the latter beginning near the mouth of the Ohio River. The eastern region has a decided and peculiar southern fauna, which is perhaps to be united with that of Cuba, and a northern fauna beginning in Pennsylvania. In the northern region there seems hardly any difference between the eastern and western parts. Nevertheless, it is certain that some species belong to more than one region, and that these regions do not coincide with the three principal groups of the genus *Cambarus*. The first group, as has been already stated, prevails in the southern parts of the western and eastern faunal region; the second group prevails partly in the northern part of the eastern faunal region.

The examination of the distribution of single species, or rather the exact determination of the circle in which every species lives and the central point which is to be taken as its most proper habitat, would be very interesting, if the materials at command were sufficiently abundant. The greatest impediment to such an examination is the scantiness of our knowledge, I may say our almost entire ignorance, of the great country comprising the Alleghany Mountains and circumjacent regions.

A detailed examination of the questions suggested being as yet impossible, I may be permitted to offer a few words upon some of the most widely spread species.

The central point of *C. acutus* seems to be the southern shore around the mouth of the Mississippi; of *C. affinis*, the Lower Potomac; of *C. virilis*, Lake Superior; of *C. propinquus*, Lake Ontario; of *C. obesus*, the middle part of the Mississippi; of *C. Bartonii*, perhaps the middle of the eastern part of the United States. Some of these so-called central points are in fact not at all central, they being either near the shore of the sea or not far from the limits, so far as we yet know, of the distribution of the species. I accordingly attach no great value to them, as they are liable very soon to be greatly modified by new explorations.

The number of species now known to belong to the old genus *Astacus* is 56. Of these there are in America, 40 (two in South America); New Holland, 11; Asia, 2; Europe, 2; Africa, 1.

As now distributed, there belong to the genus *Cambarus*, 32; *Astacus*, 13; (ASTACOIDES) *Astacoides*, 4; *Cheraps*, 1; *Engæus*, 2. The systematic position of the other species is not yet ascertained.

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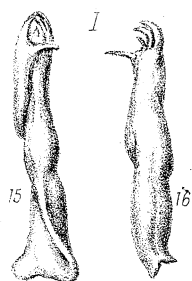
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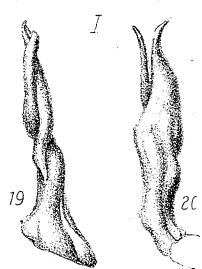
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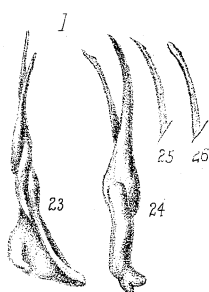
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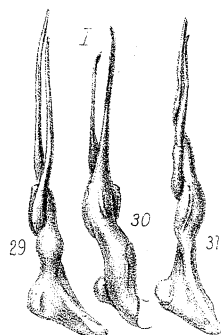
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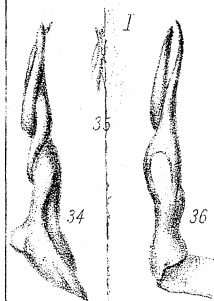
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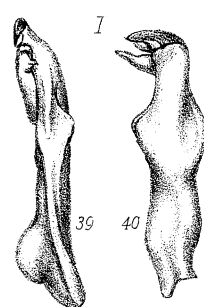
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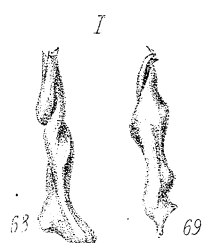
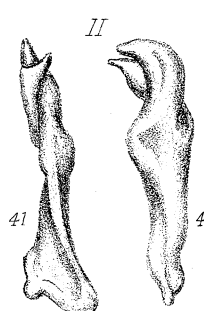
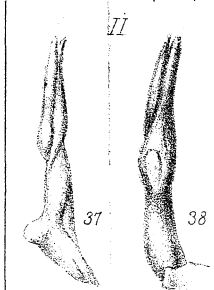
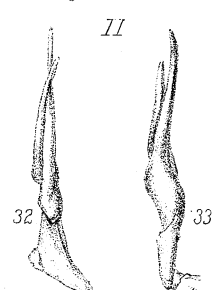
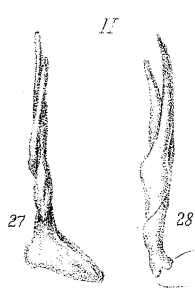
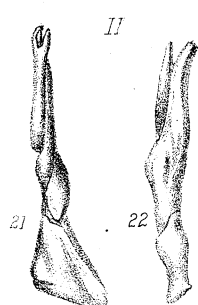
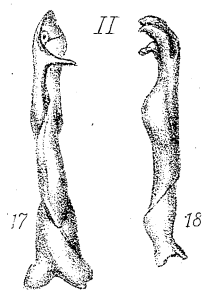
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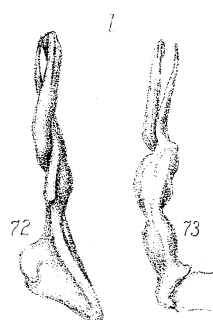
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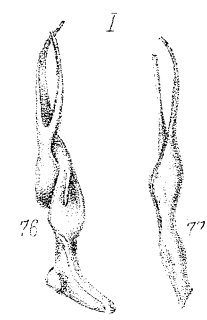
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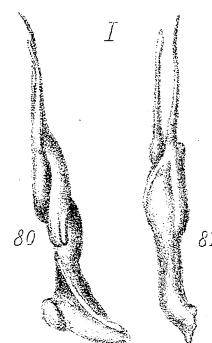
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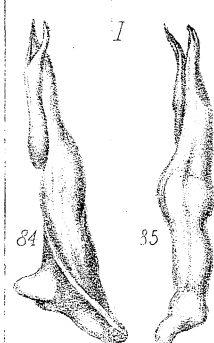
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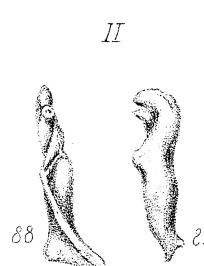
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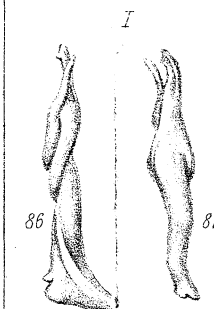
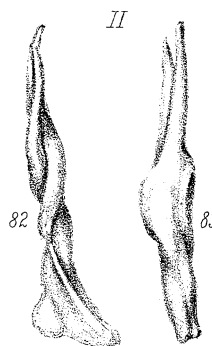
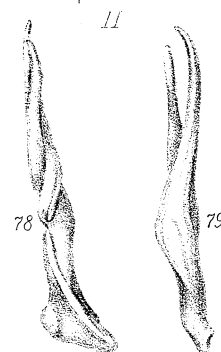
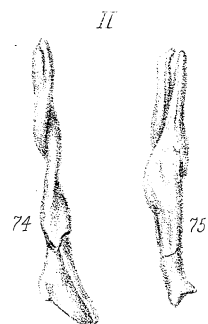
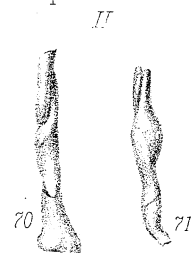
C. rusticus.



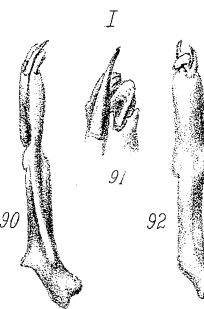
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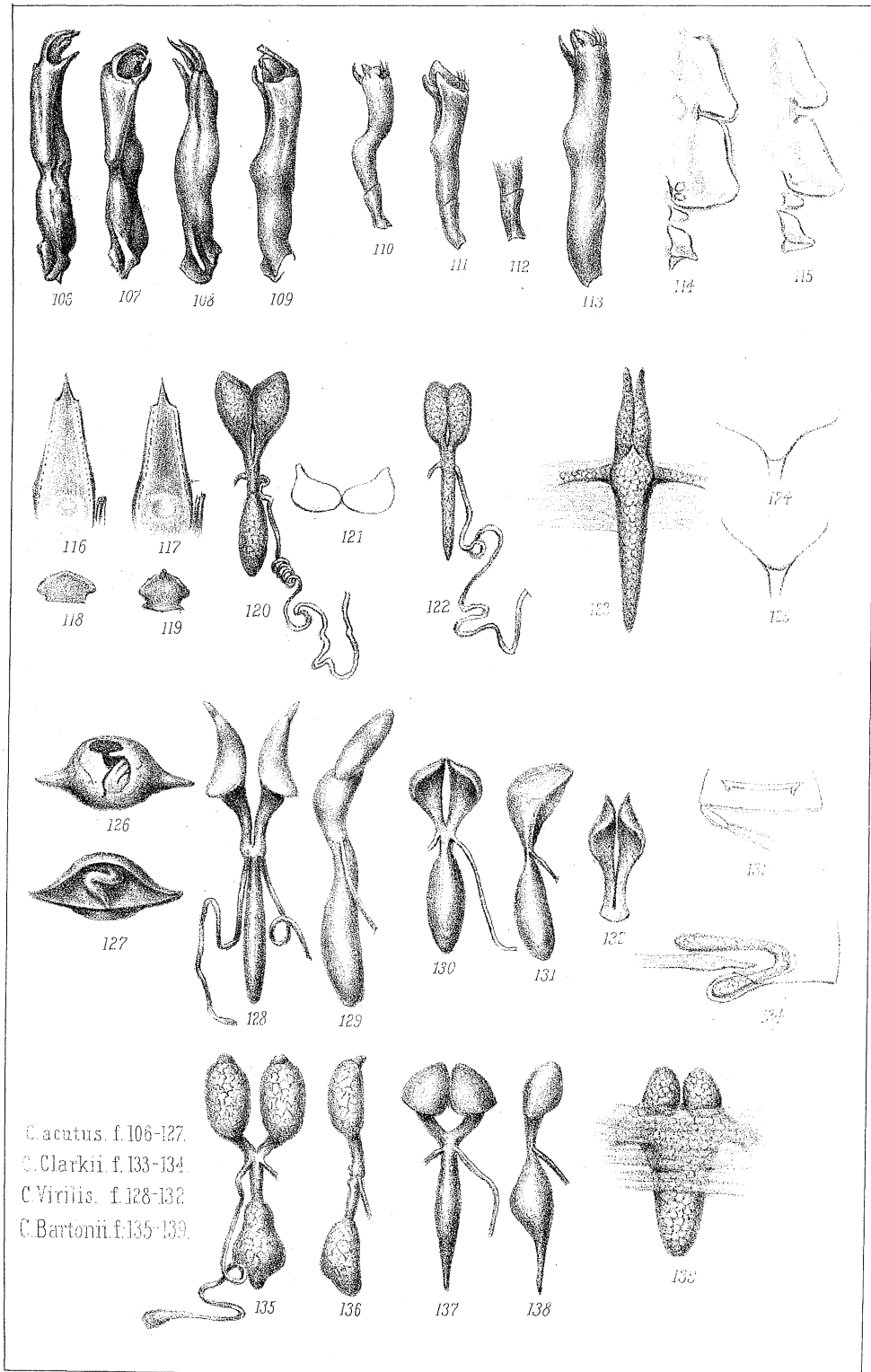
C. extraneus.



C. lancifer.

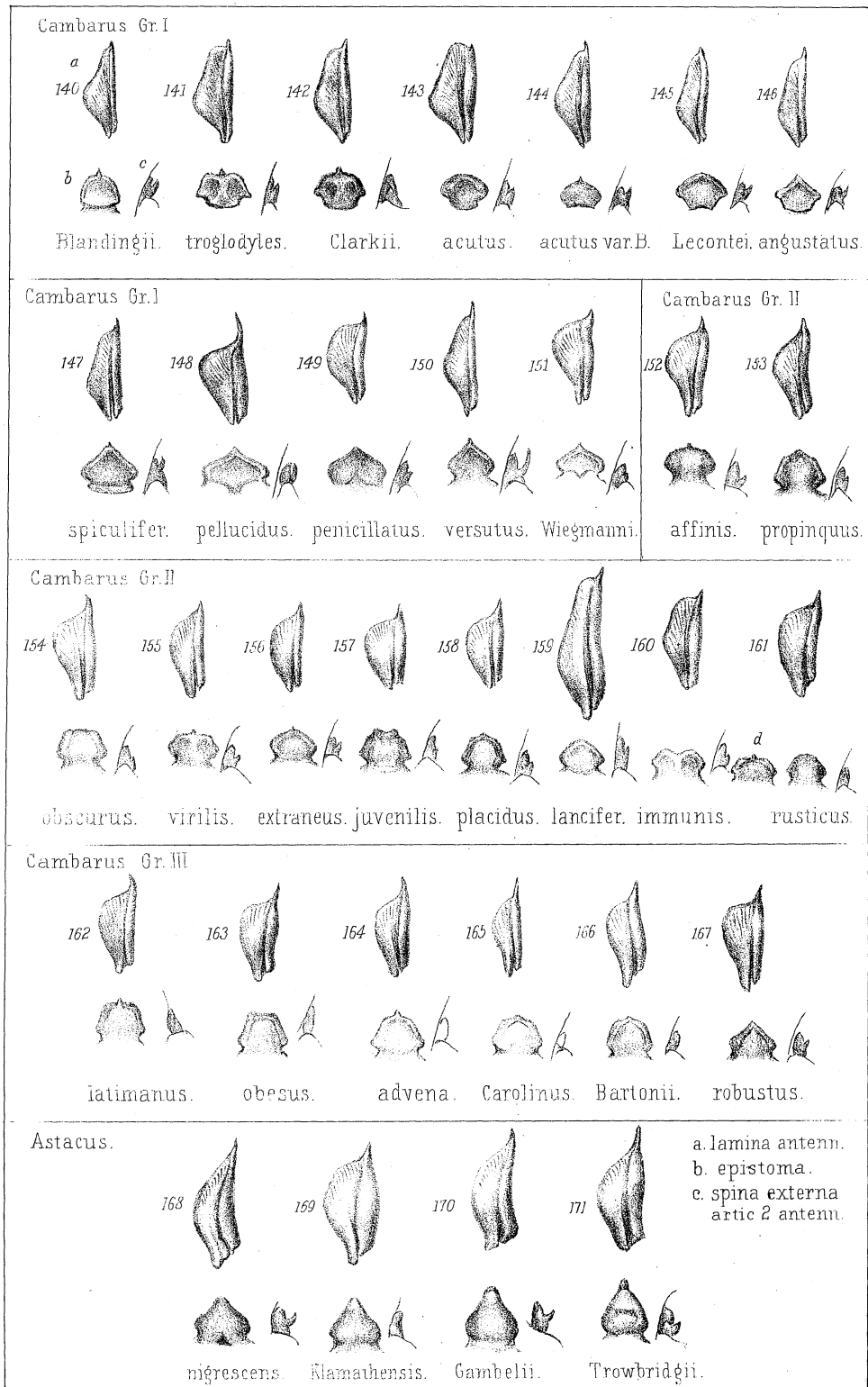


C. advena.



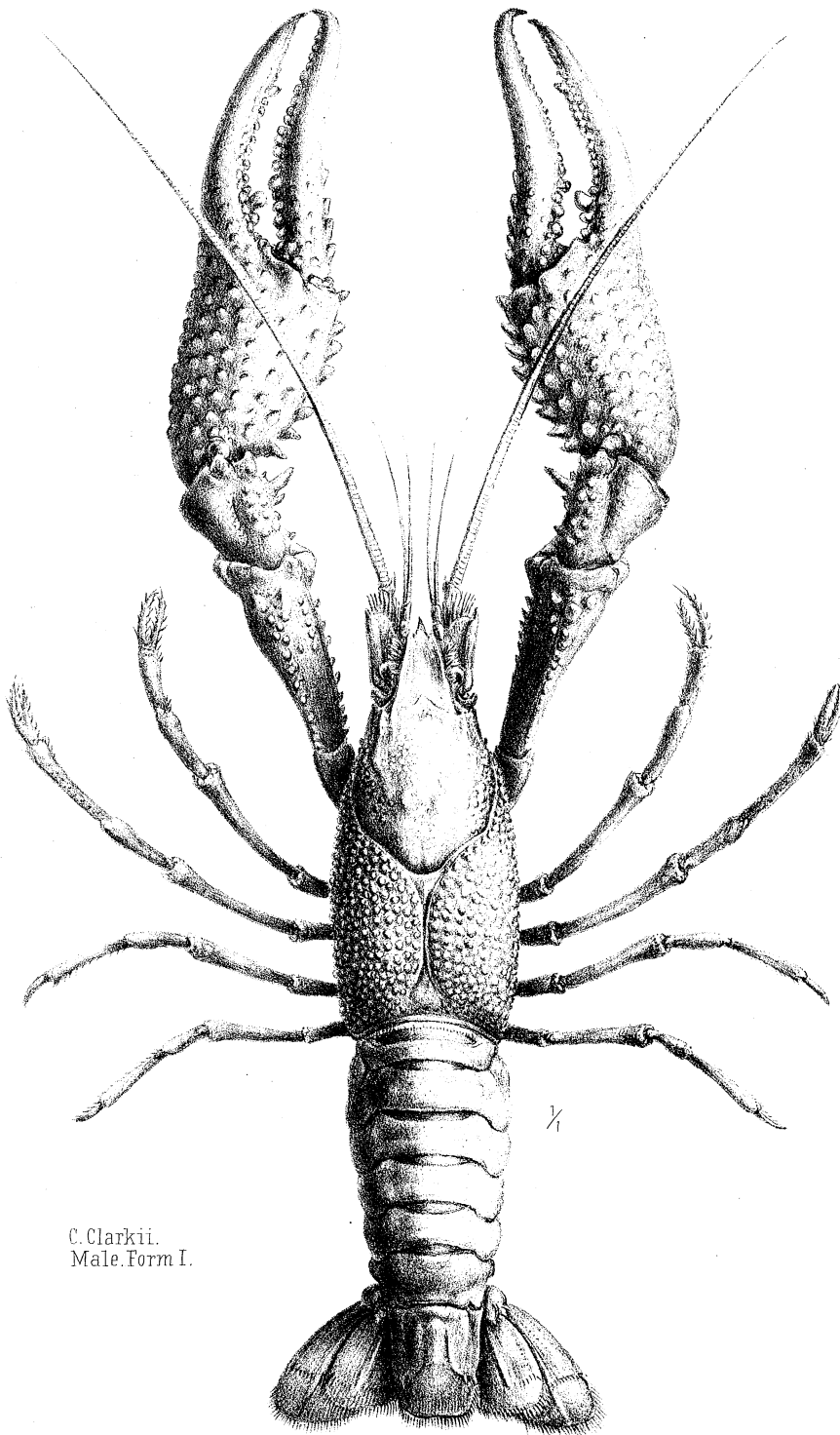
Dr. Hagen, del. - P. Roemer, on stone.

New Eng. Lith. Co. Boston.



Dr. Hagen. del. P. Roetter. on stone.

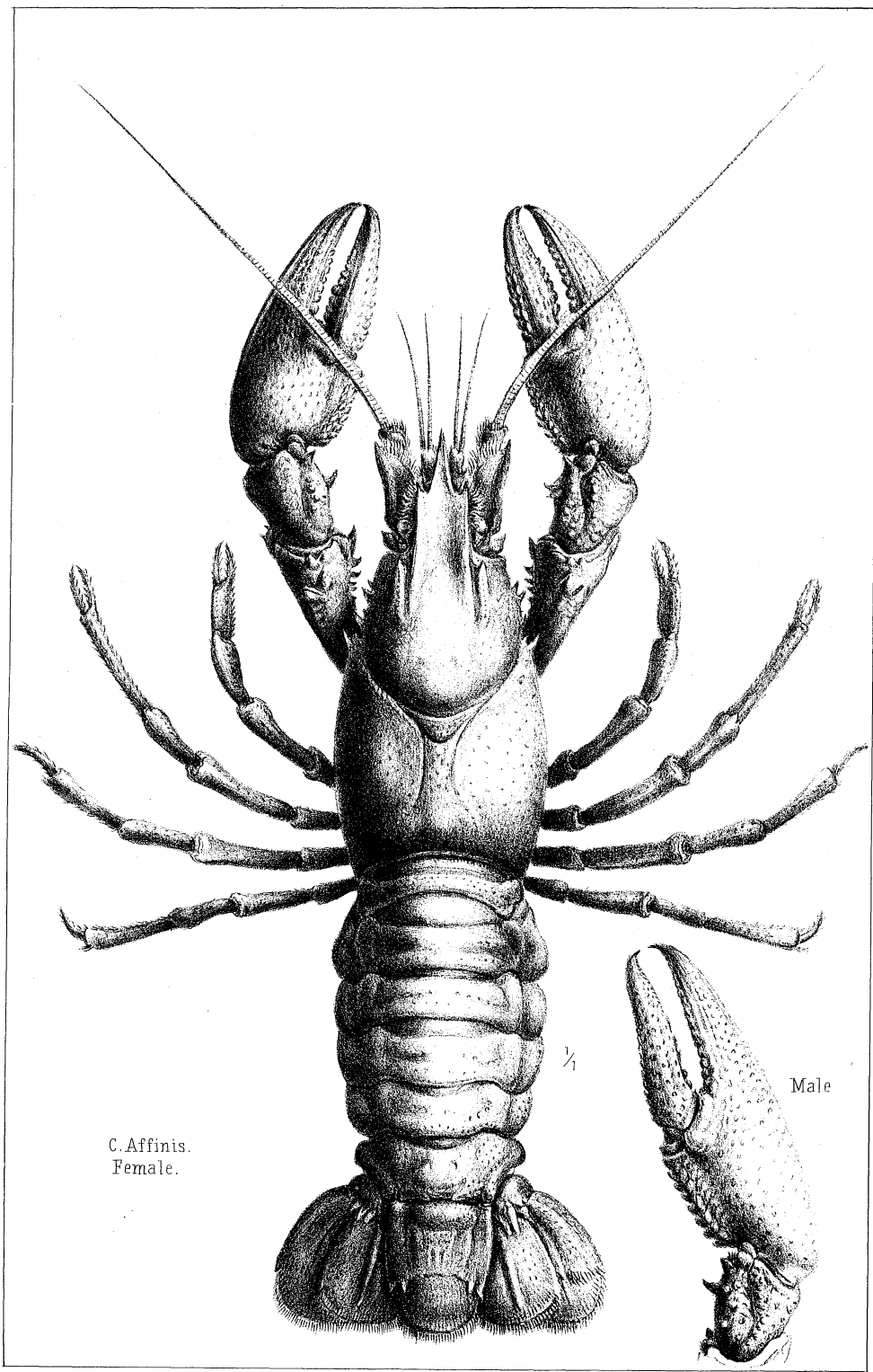
New Eng. Lith. Co. Boston.



C. Clarkii.
Male. Form I.

P. Roetter, on stone from nat.

New Eng. Lith. Co. Boston.

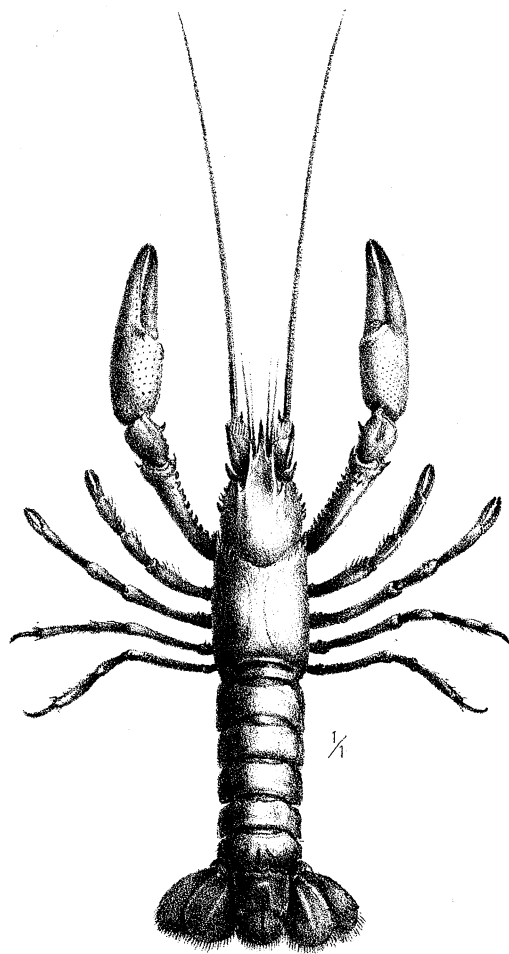


C. Affinis.
Female.

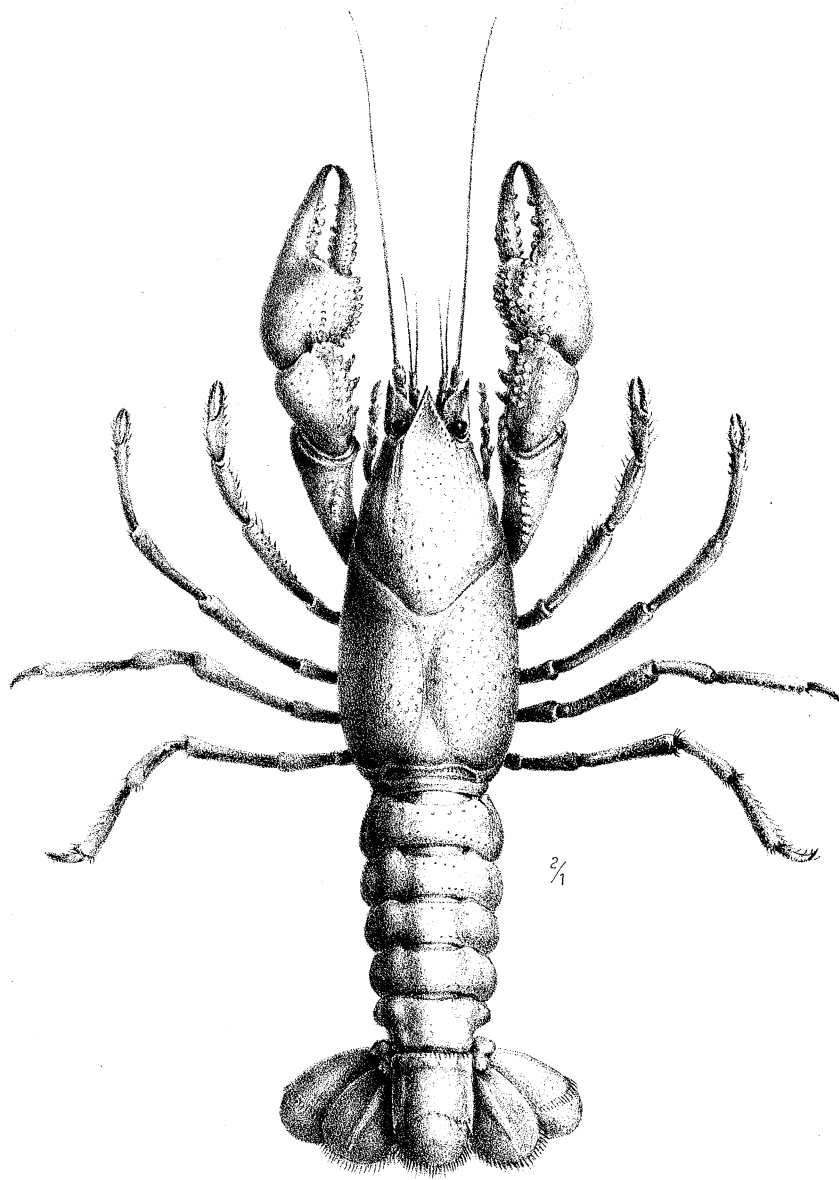
Male

E. Roetter, on stone from nat.

New Eng. Lith Co. Boston.



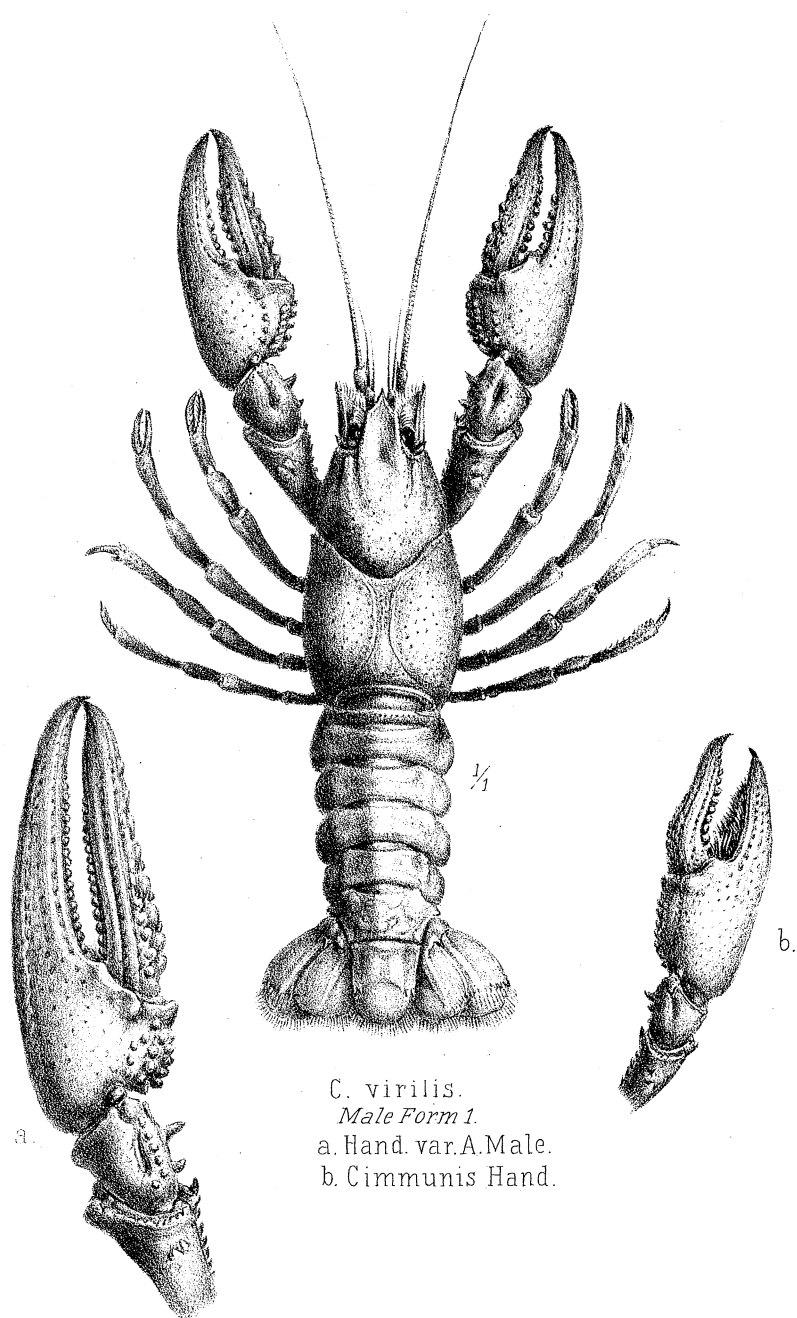
C. pellucidus Male. Form I



C. advena. Male. Form I.

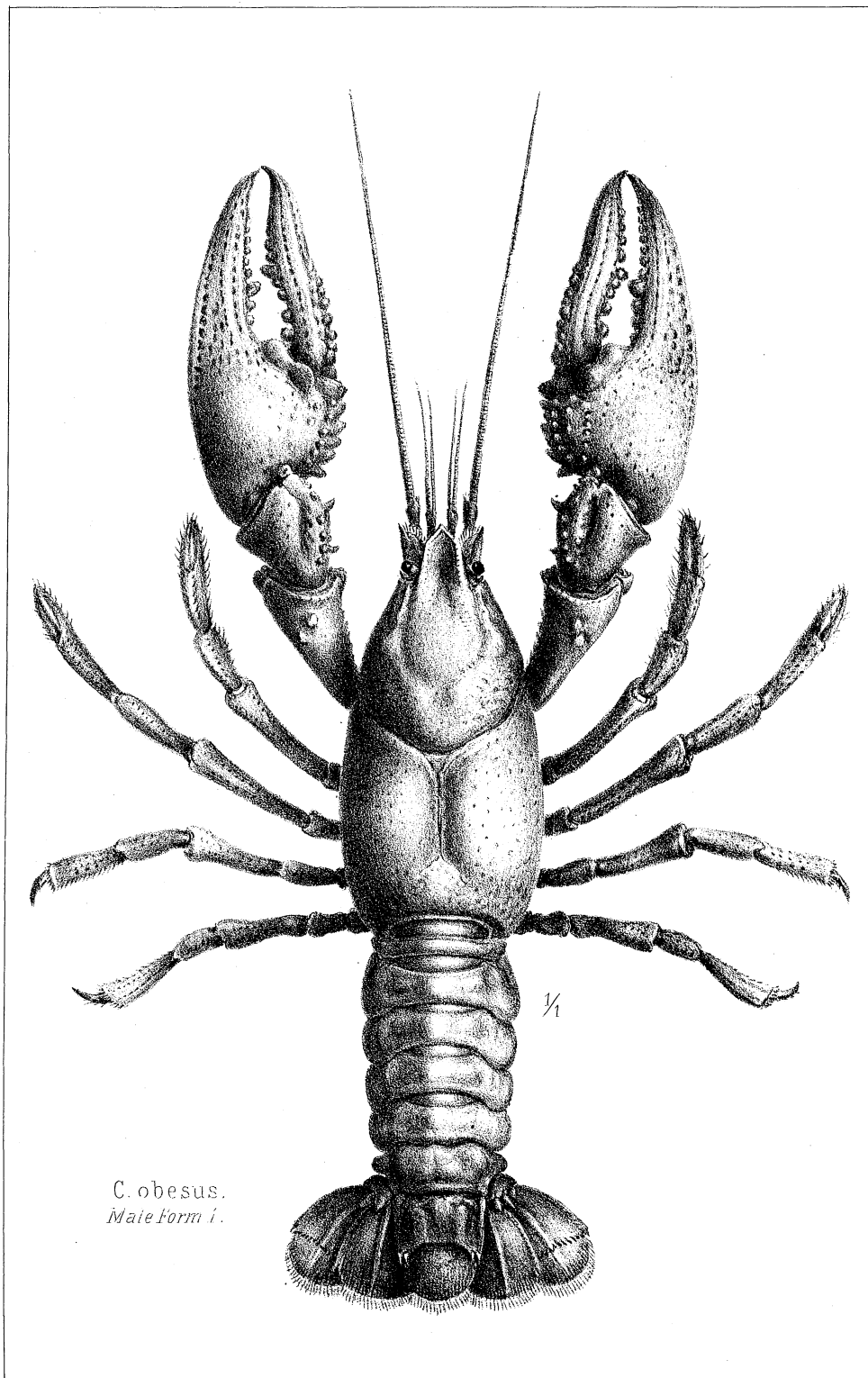
P. Roetter, on stone from nat.

New Eng. Lith. Co. Boston.



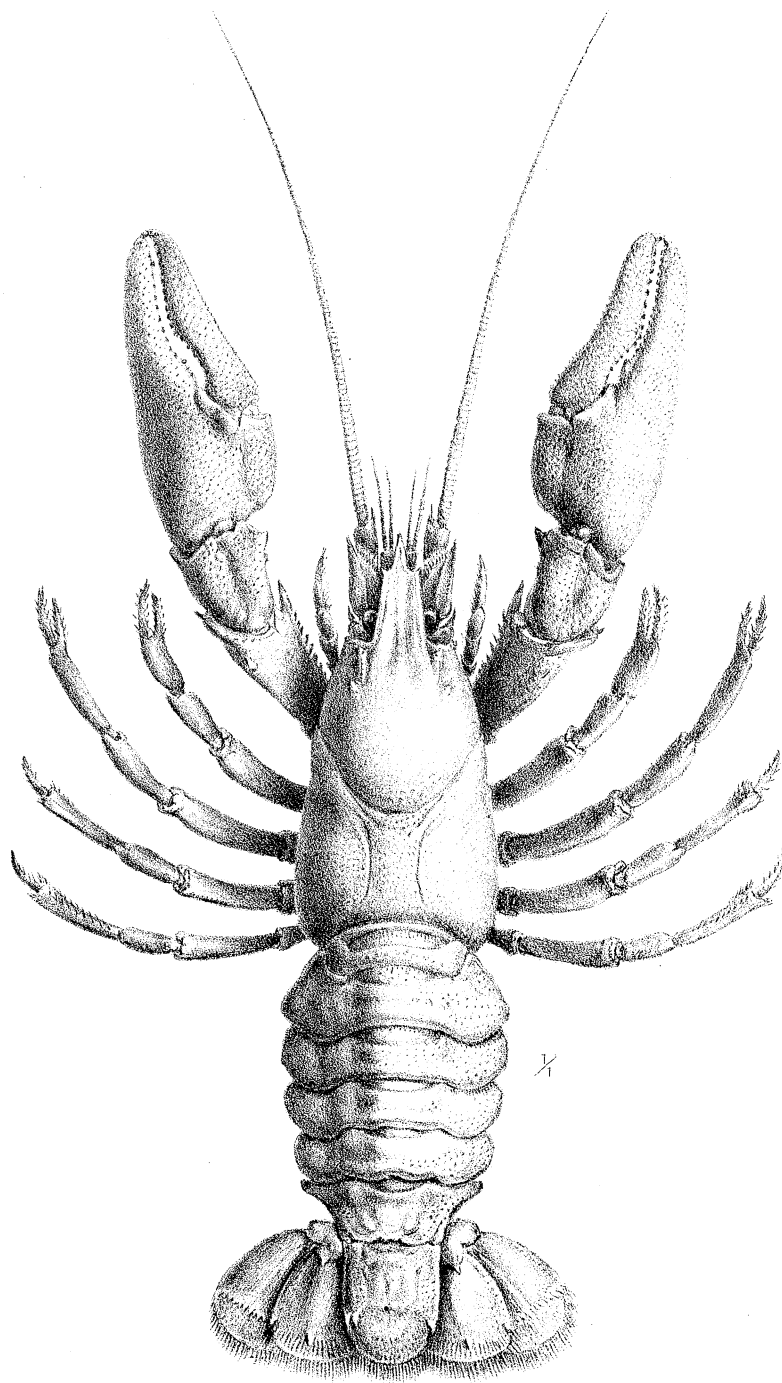
P. Roetter on stone from nat.

New Eng. Lith. Co. Boston.



P. Roetter, on stone from nat.

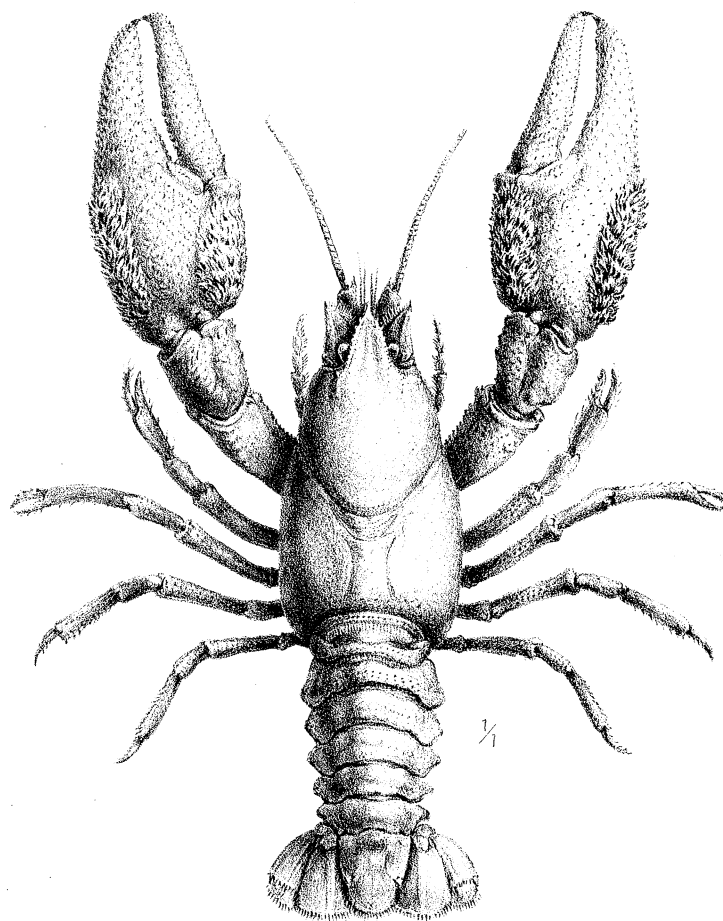
New Eng. Lith. Co. Boston.



A. Trowbridgii. Female.

P. Roetter, on stone from nat.

New Eng. Lith. Co. Boston.



A. Gambelii. Male.

ILLUSTRATED CATALOGUE

OF THE

Ann.

MUSEUM OF COMPARATIVE ZOÖLOGY,

Apr. 24, 1893

AT HARVARD COLLEGE.

No. V.

THE IMMATURE STATE OF THE ODONATA.

PART I.—SUBFAMILY GOMPHINA.

BY

LOUIS CABOT.

C A M B R I D G E :

PRINTED FOR THE MUSEUM OF COMPARATIVE ZOÖLOGY.

1872.

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UNIVERSITY PRESS: WELCH, BIGELOW, & CO.,
CAMBRIDGE.

P R E F A C E .

THE description of the immature state of the species belonging to the subfamily Gomphina is to be followed by that of the other five subfamilies of the interesting family of the Odonata. The materials in the collection of the Museum of Comparative Zoölogy are very rich, as is well shown by the Gomphina. Up to this time two species only have been published, both from Europe; now seventeen are described, viz. eleven from America, of which four are from South America, three from Asia, and three from Europe. The relation of the larvæ described to the actually described imagos is, of course, very small. Baron De Selys Longchamps, in Liège, describes in his monograph of the Gomphina, published with my collaboration, and in the two additions, one hundred and seventy species,—just ten times more than the seventeen immature species here published. But of the six legions of the Gomphina two only are not represented in this monograph,—Chlorogomphus with one species from Japan, and Petalura with three species from New Holland and North America.

Of the species described, only four are raised and identified beyond any doubt, viz. *G. vulgatissimus*, by Dr. F. Brauer; *M. spiniceps*, by Mr. Fr. G. Sanborn; *H. brevistylus*, by the late Dr. T. W. Harris; *C. bidentatus*, by Dr. F. Brauer. All the others are determined by exclusion or supposition, and some of them more or less doubtfully. The general character of the subfamily will be better given with the publication of the nearly related *Æschnina*.

I am responsible in this monograph for the determination of the species, as Mr. L. Cabot had not studied the imago before, and for the synopsis, taken from his descriptions.

H. A. HAGEN.

July 5, 1871.

BIBLIOGRAPHY.

1742. REAUMUR, Mém., T. VI., pl. 37, f. 2 to 8, p. 403, figured and described the nympha of a French Gomphus. The figures are not sufficient to determine the species.
1749. ROESEL, Insectenbelustigung, T. II., P. II., pl. 7, f. 1, 2, gives the larvæ and nymphæ of a Gomphus, perhaps *G. vulgatissimus*. Roesel believes it to belong to *Libellula depressa* or *L. cancellata*, but he states that he had several different species in the same jar, and the figured one is surely a Gomphus. The larva described by Scopoli, Fauna Carniolica, p. 259, as belonging to *Cordulegaster annulatus*, is surely an *Æschna*, and not a Gomphus.
1839. BURMEISTER, Handbuch, T. II., p. 831, gives a short notice on the larvæ of the Gomphus.
1853. H. HAGEN, Stettin. Ent. Zeit., T. XIV., p. 263, describes *G. vulgatissimus* and *C. bidentatus*, both raised by Dr. F. Brauer.
1857. F. BRAUER, Neuroptera Austriaca, p. xv., describes both species raised by him, formerly communicated to Dr. Hagen.

ODONATA.

GOMPHINA.

1. *Herpetogomphus* species.

SELYS, Monogr. des Gomph., p. 69.

Plate I., fig. 2, b, c.

Locality: Brazil, Rio dos Macacos, Thayer Expedition. Nympha, male, full grown. Mus. Comp. Zoöl. Length, 31 mm.; breadth, 7 mm.

Body *Æschna*-like, rather flat, hairy. Head cordate, flat. Eyes moderately prominent. Ocelli developed; an oblique groove extending from lateral ocellus to front angle of eye; part behind the eyes short, notched at middle, with flat spot on each side; hind angles rounded with circular tubercle. Antennæ, two basal joints short, globular; 3d long, dilated, straight, bent up a little at tip; 4th joint very short, rudimentary. Mask extending to fore legs; breadth half the length, narrower behind, sides bent up; somewhat margined; middle third of fore-border produced in rounded lobe edged with bristles, and having two small black teeth on each side of middle. Palpi small, not meeting, finely denticulated; end hooks sharp, bent down; movable hooks long, arcuated. Prothorax narrower than head, with short anterior lobe; posterior part rounded, has two quadrangular impressions. Wing-cases reaching middle of fourth segment. Legs short and strong, formed for burrowing. Hind legs more distant at base. Fore and middle legs alike; femora and tibiæ strong, somewhat bent; tibiæ longest; tarsi less than $\frac{1}{2}$ as long as tibiæ, 2-jointed, basal joint very small; claws small, sharp. Hind legs reaching 9th segment, rather flattened; tarsi 3-jointed. Abdomen long, gradually narrowing to tip, somewhat rounded above and flattened below. Segments 2 to 9 have dorsal hooks, thicker on 2d segment, nearly obliterated (accidentally?) on 6th, more marked on those following. Side-border sharp. Lateral spines on segments 7, 8, 9; Segments of equal length, 10th segment a little longer than 9th. Anal appendices long, sharp, pyramidal, 2 inferior ones as long as 10th seg.; superior a little shorter, basal half thickened above; lateral appendices $\frac{1}{2}$ as long as inferior.

As this nympha is very similar to *Gomphus*, it probably belongs to *Herpetogomphus*, which is found in South America, while *Gomphus* is not.

There is in same collection and from same locality a larva 5 mm. long, wing-cases just visible; more hairy; teeth on lobe of mask; inside of palpus more marked; dorsal hooks just visible; middle anal appendix not thickened at base.

2. *Gomphus pilipes*.

SELYS, Monogr. des Gomph., p. 148.

Plate I., fig. 3, a, b, c.

Nympha, full-grown female. Locality: S. Carolina. Coll. Hagen. Museum Comp. Zoöl. Length, 25 mm.; breadth, 10 mm.

Body flat, lanceolate, sparingly covered with hairs. Head cordate, flat. Eyes rather prominent, large. Ocelli developed. Vertex flat, an oblique groove extending from lateral ocellus to front angle of eye. Antennæ, two basal joints globular, 2d a little shortest, 3d twice as long as both basal, straight, 4th rudimentary. Part behind eyes short, notched at middle, hind angles rounded, 2 flat tubercles near hind-border. Mask reaching fore legs, small, oblong, sides bent up; fore border produced at middle third in small rounded lobe, with comb of bristles. Palpi short, not meeting; end hook not longer than denticulations; movable hooks thin, sharp, long. Prothorax narrow, oval, border elevated at sides. Wing-cases reaching to middle of 4th segment. Legs strong, hairy, formed for burrowing. Hind legs more separated at base. Fore and middle legs of equal size, short; femora short, strong, arcuated; tibiæ a little longer, nearly straight; tarsi very short, 2-jointed. Hind legs reaching 8th seg., flat; tarsi 3-jointed; claws short, sharp. Abdomen flat, broad, narrowing after 6th segment. Segments 9 and 10 very contracted. Segments have three spots on each side, 9th a linear spot. No dorsal hooks. Segments 8 and 9 have lateral spines. Side-border sharp. Segments of equal length except two last; 9th longer than 8th; 10th $\frac{1}{2}$ as long as 9th; nearly cylindrical. Anal appendices very short, not $\frac{1}{2}$ as long as 10th segment, pyramidal, sharp, nearly equal in length. Two lateral a little shorter. A small bifid tubercle at end of eighth ventral segment.

Another specimen from South Carolina, Coll. Hagen, is identical, but smaller; 25 mm.

These nymphæ are, of course, only referred to *G. pilipes* as probably belonging there or to a related species.

3. Gomphus vulgatissimus.

SELYS, Monogr. des Gomph., p. 129.

Plate I., fig. 1, b, c.

Nympha, male. Length, 31 mm.; breadth, 8 mm. Locality: Europe. Raised by Dr. Brauer, female. Coll. Hagen.

Head cordate, flat. Eyes large, prominent. Ocelli developed. Oblique groove extending from lateral ocellus to front angle of eye. Vertex square, a little elevated. Part behind the eyes short, notched at middle; small elevated spots behind eyes. Antennæ, two basal joints short, globular, 2d shortest, 3d nearly twice as long as both basal, dilated, somewhat bent up at tip, 4th rudimentary. Mask reaching to the fore legs, quadrangular, channelled in middle, sides bent up, cut straight at fore-border, middle third finely denticulated, and surmounted by comb of bristles. Palpi short, arcuated, finely denticulated at basal half, end hook stout; movable hooks long and sharp. Prothorax oval, fore-border elevated, a flat impression on each side. Wing-cases reaching nearly to 4th segment. Legs strong, formed for burrowing. Hind legs more widely separated at base. Fore and middle legs short, about equal size. Femora short, stout, bent inward; tibiæ longer, with strong outer spine at anterior end; tarsi 2-jointed, short, basal joint very short, claws sharp. Hind legs longer, reaching nearly to 9th segment, flat; tarsi 3-jointed, 2d, half the length of 3d. Abdomen long, flat, lanceolate, decreasing in size after 6th segment. Side-border sharp; segments 2 to 9 with large flat spots. No dorsal hooks. Segments 6 to 9 with lateral spines; spines of 9th $\frac{1}{2}$ as long as 10th segment. Segments of equal length, except 10th, which is small, about $\frac{1}{3}$ of foregoing, and cylindrical. Anal appendices a little longer than last segment, pyramidal, sharp. Superior one thickened at basal half; lateral superior ones shorter, sharp.

Have seen both sexes. Female has abdomen a little broader, and at end of 8 ventral segment a small bifid tubercle, superior appendix not thickened at basal half.

4. Gomphus species.

Plate II., fig. 4, b.

Nympha, 31 mm.; breadth, 6 mm.

Locality: Rock Island, Illinois. Coll. Hagen. Mr. Walsh supposed this nympha, judging from perfect insects found in vicinity, to belong either to *G. vastus*, *fluviatilis*, *amnicola*, or *fraternus*.

Very similar to *Gomphus vulgatissimus*, differs in having less prominent tubercles on occiput. Denticulation of palpi deeper. Wing-cases reaching 4th segment. Abdomen considerably narrower, more rounded above; 8th and 9th segments with tubercles on dorsal line, lateral spines on 9th longer than 10th segment, which is very short; 9th segment a little longer than 8th. Anal appendices a little shorter than in *G. vulgatissimus*. Hind legs extending to 8th segment only.

5. *Gomphus* species.

Plate II., fig. 5.

Nympha full grown, 24 mm. long, 6 mm. broad, similar to *G. vulgatissimus*. Locality: Massachusetts. Coll. Mus. Comp. Zoöl., and Coll. Hagen.

Body tapering less abruptly. Head with flat spots instead of tubercles on occiput. Wing-cases reaching middle of 4th segment. Legs rather more slender. Dorsal hooks on segments 6 to 9; on the other segments rudimentary. Lateral spines on segments 7 to 9; 9th segment longer than 8th, with lateral spines nearly as long as 10th, which segment is rather longer than in *G. vulgatissimus*.

There is another, from same collection, younger, 21 mm. long.

6. *Gomphus* species.

Plate II., fig. 6, b.

Nympha. Length, 24 mm.; breadth, 7 mm.

Locality: Pole Creek, W. Texas. Coll. Hagen.

Body flat. Head flat, cordate. Eyes rather prominent. Ocelli developed. Part behind eyes rounded. Antennæ, two basal joints globular, 2d smallest, 3d elongated and enlarged, 4th small, rudimentary. Whole head granulated. Mask extending to fore legs, length greater than breadth, moderately channelled in middle, middle third somewhat produced, with comb of bristles. Palpi enlarged and rounded at ends, very finely denticulated. Movable hooks long and sharp. Wing-cases extending to middle of 3d segment. Legs strong. Hind legs more separated at base. Middle and fore legs of nearly equal size, strong, formed for burrowing. Femora and tibiæ arcuated. Tibiæ with strongly marked end spine; tarsi 2-jointed; claws sharp. Hind legs reaching 9th segment; tarsi 3-jointed. Abdomen flat, tapering. Dorsal hooks on all segments except 10th. Lateral spines on segments 7 to 9. Segments of nearly equal length. Lateral spines of 9th much

shorter than the 10th segment. Anal appendices longer than 10th segment, pyramidal, sharp, of nearly equal length. Lateral superior appendices nearly as long as the others.

7. *Gomphus* species.

Plate II., fig. 2, b, c, d.

Nympha, full grown. Length, 22 mm.; breadth, 7 mm.

Locality: Himalaya, Ghugger Pir, Rev. M. M. Carleton. Coll. Mus. Comp. Zööl.

Body flat, lanceolate. Head cordate. Eyes large, very prominent. Ocelli indistinct. Vertex flat, two small impressions at fore part. Part behind the eyes short, rounded laterally; hind angles blunt; two flat impressions on each side of median line. Antennæ, two basal joints globular, 2d smallest, 3d long, dilated, bent up, 4th very small, black, cylindrical. Mask extending to fore legs, length greater than breadth, narrower behind, deeply channelled at fore-border, sides bent up; middle 3d of fore-border produced in elliptical lobe, deeply cleft in the middle, with comb of bristles thickened at base. Palpi strong, with sharp, bent hooks; some molar incisions; movable hooks long, bent, sharp. Prothorax oval, narrower than head, rounded, flat. Wing-cases reaching 4th segment. Legs formed for burrowing. Hind legs more widely separated at base. Fore and middle legs stout, about equal in size. Femora and tibiæ arcuated, tibiæ are without the sharp lateral spine at end; tarsi knife-shaped, 2-jointed; claws sharp. Hind legs tarsi 3-jointed, straight. Abdomen flat, dorsum slightly rounded, tapering gradually. Side border sharp. Segments 5 to 9, with lateral spines; no dorsal hooks. Segments of nearly equal length, 10th small, short, cylindrical. Lateral spines of 9th are $\frac{1}{2}$ length of 10th. Anal appendices a little longer than 10th; equal length, pyramidal, sharp. Superior appendix with two tubercles near the tip. Lateral short and sharp.

8. *Macrogomphus* spiniceps.

Nat. Hist. Soc., Phil., 1862, p. 889.

Plate II., fig. 1, a, b, c.

Nympha. 41 mm. long; 8 mm. broad.

Locality: Taken in transformation by Mr. F. G. Sanborn, July 4, 1867, at Lawrence, Mass.

Body long, narrow. Head cordate. Eyes large, prominent. Ocelli developed. Antennæ, somewhat shorter than head, two basal joints short, globular; 3d twice as long as two preceding, dilated, bent inward at tip, 4th joint rudimentary. Vertex flat; outside of ocelli are visible small tubercles, apparently where the spines of imago are placed. Mask extending to fore legs, somewhat longer than broad, channelled in middle; fore-border a little broadest, cut straight; middle 3d with comb of short hairs. Palpi short, strong, arcuated; tip forming strong bent hook, denticulated just before the end; movable hook as long as palpus, sharp. Prothorax somewhat smaller than head, nearly square, narrowed a little in front, sides and angles rounded; two flat impressions near the front and hind borders. Wing-cases nearly reaching the 4th segment. Legs short, strong, hairy. Hind legs more separated at base; fore and middle legs of equal length, shorter than hind legs; femora very short, bent; tibiæ similar and longer; tarsi nearly $\frac{1}{2}$ as long as tibiæ, 2-jointed; claws bent; the outside claw shorter and stronger than inner one. Hind legs reaching 6th segment, nearly straight, tarsi 3-jointed; basal joint short, two others of about equal length. Legs formed for burrowing. Abdomen somewhat conical, tapering. Segments 1 to 8 nearly equal length, 9th nearly twice as long, narrowed in middle; 10th short and slender; large flat spots on segments 2 to 8; segments 6 to 9 with lateral spines. No dorsal hooks. Anal appendices as long as 10th segment, pyramidal, the two lower broader, not very sharp. All of equal length and like shape.

Male nympha has sexual parts visible on 2 and 3 ventral segments; the opening of sexual parts on middle of 9th; in the female a bifid knob on the articulation between 8 and 9 is visible.

9. *Progomphus*?? species.

SELYS, Monogr. des Gomph., p. 194.

Plate II., fig. 3, a, b, c.

Nympha, full grown male and female. Length, 30 mm.; breadth, 7 mm. Looks rather like *Æschna*.

Locality: Wareham, Mass. Mus. Comp. Zool.

Head stout, rather square, narrowed forward. Eyes not very prominent. Ocelli very well developed. Vertex flat, with irregular hairy spots. Antennæ stout, two basal joints small, globular, 3d long, dilated, very hairy, 4th small, $\frac{1}{4}$ length of 3d, cylindrical, recurved. Behind each eye a circular elevated spot, and between these, two impres-

sions on occiput. Mask extending to fore legs, narrow; length twice the breadth; somewhat enlarged forward, with middle channel widening forward; front border produced in semicircular lobe, edged with hairy comb; the hairs forming this are enlarged at tip and flattened, inserted in small basal cylinder. Palpi short, bent, ending in blunt hooks, smooth inside; movable hooks long, sharp. Prothorax nearly circular, rounded at fore-border, with two oblique impressions; side-border very slightly raised; prothorax polished, shining, near borders and middle line slightly granulated. Wing-cases extending beyond 4th segment. Legs stout, short, hairy, typical burrowing legs. Hind legs much more widely separated at base than fore and middle legs; middle legs nearer at base than fore legs. Fore legs somewhat stronger than middle legs, the coxæ being highly developed, and the femora triangular, arcuated and dilated at base. Tibiæ thickened at middle, near the end bent and narrowed; tarsi somewhat shorter and bent up; 1st joint very short, 2d long, knife-shaped; hooks stout, rather blunt, outer hook rather shortest. Middle legs similar in shape, coxæ smaller, femora narrowed at base. Hind legs reaching 8th segment, similar in shape to the other legs, flatter. Tarsi 3-jointed, longer than tibiæ; claws sharp.

Abdomen as in *Æschna*, venter flattened, dorsum rounded, largest at 5th segment, tapering toward end. Segments 1 to 9 with strong dorsal hooks. Side-border sharp. Segments 5 to 9 have lateral spines. 9th and 10th ventral segments not hollowed beneath, polished. The three anal appendices rather longer than 10 segment, pyramidal, sharp, of equal length; two lateral ones half as long, blunt, pyramidal.

This nymph is distinguished by highly developed burrowing legs, fore legs strongest; coxæ, femora, and tarsi much developed. Middle legs are nearest together at base, a peculiarity also distinguishable in *Gomphoides*. Hind legs highly developed. Abdomen exactly like *Æschna*. Segments of equal length, 10th perhaps a little shorter. Ventral 9th not making part of the hollow of rest of abdomen; stigmata placed outside of hind angles of prothorax. Shape of antennæ and mask refer this nymph to *Legion Gomphoides*. It might be supposed to belong to genus *Progomphus*, if that genus were found in New England.

A female nymph not fully grown, 25 mm. length, precisely like foregoing, but darker in color, from Carundahy, Brazil, Thayer Exp., is in the coll., unless some mistake in locality has been made in the label.

10. Gomphoides species.

SELYS, Monogr. des Gomph., p. 208.

Pl. I., fig. 5, a, b, c, d.

Nympha, male. Length, 36 mm.; breadth, 6 mm. Skin split, showing the imago.

Locality: Sta Cruz, Brazil. Thayer Exp. Mus. Comp. Zool.

Body long, slender. Head cordate, hairy, nearly as broad as the body. Eyes large, prominent. Ocelli well developed. Antennæ rather short, two basal joints globular; 3d twice as long, strong, dilated; 4th short, linear. Vertex flat; in front of anterior ocellus an impression; behind the eyes on occiput an oval depressed spot. Mask reaching half-way between fore and middle legs. Breadth half the length, enlarged in front, middle much produced in semicircular lobe, with fringe of bristles. Palpi short, arcuated, not denticulated; movable hooks longer than palpus and sharp. Prothorax oblong, breadth rather greater than length, sides and angles rounded; two oblique impressions in front and one behind at middle. Wing-cases reaching middle of 4th segment. Legs short, strong, hairy; hind legs more widely separated at base; fore and middle legs of equal size; femora stout and arcuated, enlarged at middle; tibiæ somewhat longer, angular. Tarsi shorter, basal joints very small, 2d longer, knife-shaped, bent outward; claws very small, strong, rather blunt; tibiæ and tarsi have black spines on outer side. Legs formed for burrowing. Hind legs more slender, reaching 6th segment; femora and tibiæ straight; tarsi 3-jointed, 2d shorter than 3d, claws longer, pointed. Abdomen conical, venter less rounded than dorsum, tip extremely tapering. Segments of nearly equal length, gradually decreasing, except 10th, which is longer than 7th, 8th, and 9th together, and nearly cylindrical. Side-edges rather prominent. Segments 7, 8, and 9 have lateral spines. Segments 4, 5, and 6 have dorsal spines, strongest on 4 and 5. Anal appendices pyramidal, short, sharp, all five of equal length. Sexual parts are visible on 2 and 3 ventral segments.

This nympa belongs perhaps to the genus *Gomphoides* (sub-genus *Aphylla*) *brevipes* Selys, the imago of which has the 10th segment of equal length to 9th, while the others, from Brazil, have 10th segment shorter. A nearer determination is not at present possible.

11. Gomphoides species.

There are three female nymphæ, not quite full grown, belonging to a different species, similar to the foregoing and somewhat smaller, differing in having dorsal spines on segments 4 to 9. Locality: Rio dos Macacos, Brazil. Thayer Ex. Mus. Comp. Zoöl.

HAGENIUS.

SELYS, Monogr. des Gomph., p. 238.

Body exceedingly flat, nearly circular. Head cordate. Eyes set at back of head. Antennæ very peculiar; two basal joints short, cylindrical; 3d flat, dilated, plate-shaped; 4th very rudimentary, not to be seen unless much magnified. Mask extending to fore legs, square, flat, bent up at sides, front border produced at middle. Palpi small, inner border not denticulated, tip rounded, blunt; movable hook sharp, somewhat longer than palpus. Middle legs more separated at base than fore legs; formed for running. Abdomen very flat, enlarged, nearly circular. The outer edges of segments forming a sharp-edged border, separated from abdomen by marked ventral ridge. 9th segment longer than 8th, 10th small, cylindrical, and entirely inserted in 9th. Anal appendices a little longer than 10th segment.

12. Hagenius brevistylus.

SELYS, Monogr. des Gomph., p. 241, No. 86.

Plate III., fig. 4, a, c, d.

Locality: North America. I have seen 8 nymphæ, very young and full grown, length, 12 mm. 40 mm., from Massachusetts, New York, and Osage, Kansas, all females. In the collection of the late Dr. T. W. Harris, in the Boston S. N. H., is preserved the skin of a nympha with the imago raised by him. Coll. Mus. Comp. Zoöl. Coll. Harris. Coll. Hagen.

Body very flat, broad. Head cordate, flat, breadth and length equal; between the antennæ a narrow projection, with rectangular notch at front, inserted in which a cordate tubercle. Eyes situated at hind part of head, moderately large. Antennæ short, broad; the 2 basal joints short, 3d much dilated, flat, circular, with inner edge cut straight; border somewhat elevated, covered with short scale-like hairs; at the

tip a rudimentary 4th joint, only to be seen when much magnified. Vertex flat, ocelli visible. Occiput short, hind-border notched; median line impressed, on each side a small conical tubercle; lateral hind-angles elevated, pyramidal. Mask square, somewhat produced at fore-border. Palpi small, not denticulated, blunt; hook sharp, longer than the palpus. Prothorax narrow, excavated, hind border a little rounded; a transverse impression near fore-border. Legs formed for running, flat, slender. The fore and middle legs short; the fore legs shortest; femora flattened, edged with white hairs; tibiæ angular, longer than femora; tarsi half as long as tibiæ, 2-jointed, basal joint very short. Hind legs long, femora reaching nearly to 7th segment; tibiæ of equal length to femora, tarsi 3-jointed, basal short, 2d longer, 3d equal to both in length. Wing-cases reaching 6th segment. Abdomen lancet-shaped, exceedingly flat, broader than head, nearly circular, dorsum somewhat elevated. Segments of nearly equal length, excepting 10th, which is very small and inserted in 9th. Segments 5 to 6 broadest, the others decreasing, the 9th nearly triangular. The outer edges of segments 2 to 8 form border, sharp and pointed at hind angles. Dorsal hooks prominent, flattened laterally and bent backward, less prominent on 7th to 9th segments. Anal appendices short, stout, pyramidal, blunt, a little longer than 10th segment. Superior somewhat shorter, channelled at sides, lateral very small, half as long as the others. The 8th ventral segment has small bifid vulva lobe.

13. *Hagenius* (*Sieboldius*) *japonicus*.

SELYS, Monogr. des Gomph., p. 244, No. 87.

Plate III., fig. 5, c.

Locality: Kanagawa, Japan. Coll. Mus. Comp. Zoöl. One nymph, male, not full grown. Length, 28 mm.

Very similar to *H. brevistylus*, differs as follows: Head a little shorter; hind end of the part between antennæ less deeply notched; inserted tubercle rounded; 3d joint of antennæ not so rounded. Hind angles of occiput blunt. Abdomen straighter at sides, 9th segment shorter; lateral angles of 9th not so sharp. Dorsal hooks modified in flattened tubercles. Anal appendices sharper, superior bluntest, not so deeply channelled at sides; the tip seems to be broken, before the tip are three rounded tubercles; perhaps this is a sexual character; wing-cases reaching to middle of 3d segment only. As a species *Hagenius japonicus* is found in Japan, this nymph is supposed to be the incomplete insect.

14. *Ictinus* species.

SELYS, Monogr. des Gomph., p. 263.

Plate I., fig. 4, a – e.

Nympha, male. Length, 23 mm.; breadth, 10 mm. Locality: doubtful. Coll. Hagen; middle Himalaya, Rev. M. M. Carleton. Coll. Mus. Comp. Zoöl.

Body short, stout, roof-shaped. Head large, cordate, with straight line behind the eyes; the fore part of head, including eyes, triangular, nearly equilateral; part behind the eyes half as long as that before, narrower next the prothorax. Eyes rather prominent, moderately large, triangular; part between the eyes same breadth as eyes. Sides of the head, with small prominent tubercles below the eyes. Ocelli developed. Vertex flat, sloping forward. Antennæ shorter than the head, 2 basal joints globular, 2d half the size of 1st; 3d twice as long as the two preceding, dilated, flat above. At under side of tip a small tubercle, perhaps rudimentary 4th joint. Occiput rather rounded above, sides oblique, hind border notched in middle, hind angles rather blunt. Upper lip stout, broad; base of mandibles heavy, not covered by upper lip; the basal part of head below the mandibles forming a point at each side; basal part of maxillæ not covered by mask. Mask extending between the fore legs, large, nearly square, a little smaller behind; flat, sides bent up; fore-border nearly straight, middle 3d a little produced, slightly denticulated. Palpi short, with bent and rather blunt point, inside finely denticulated; movable hooks long, sharp, arcuated. Prothorax not so broad as head, in general shape semicircular; fore-border forms transverse triangular lobe; hind-border thickened and bent up; the prothorax forms at sides beneath the eyes a protuberance. Meta and mesothorax coming together in elevated ridge. Wing-cases reaching 7th segment. Legs long, slender, formed for running; hind legs more separated at base than the others; femora of fore legs a little arcuated; tibiæ angular, somewhat longer; tarsi $\frac{1}{2}$ as long as tibiæ, basal joints very small, hooks strong and sharp. Middle legs similar, but somewhat longer; hind legs a little longer than the abdomen, straight, flat. Tarsi only two joints, basal very short. Abdomen ovoid, base contracted, broadest at 7th segment, 8th and 9th rounded off toward end of abdomen. Dorsum elevated, roof-shaped. Median line in segments 7 to 9, elevated in flattened hooks, pointed at end of segments. Side-border of abdomen sharp, with lateral spines on segments 7 to 9, similar to Hagenius. Segments 2 to 5 short, following longer; 10th very short and entirely inserted in 9th, sides of segments 2 to 9 with

smooth spots. Anal appendices short, a little longer than spines of 9th segment, pyramidal, sharp, the lateral superior ones a little shorter, the superior middle one with two polished tubercles in the middle of the side-border, perhaps a sexual character. Abdomen beneath hollowed out, but shallow; edges of segments sharply defined.

This larva is extremely interesting. The 2-jointed tarsi of hind legs are exceptions in the whole family; the general shape of body is more like *Libellulidæ*. The antennæ belong to *Gomphus*, and the mask also. Stigmata behind prothorax free. The whole body finely granulated. The figure and the description are taken from a dry specimen supposed to be from Brazil (the locality not given), and to belong perhaps to *Zonophora*. There has just arrived a collection from the middle Himalaya, Sutledge, sent by Rev. M. M. Carleton, containing several specimens in alcohol, all agreeing perfectly with the described specimen. It seems not impossible, indeed probable, that the species belongs to the genus *Ictinus*.

CORDULEGASTER.

Head transverse, oblong. Eyes conical, placed at anterior lateral angles. Antennæ seven articulated, filiform. Between the antennæ the head forms a flat, semicircular projection. Mask extending a little beyond the middle legs, spoon-shaped, covering the mouth, upper lip, and front of head as far as the antennæ. Palpi in general shape triangular, much dilated forward, and furnished at outer edge with long teeth of unequal length, slightly bent inward, and fitting closely in an irregular line into those of opposite palpus; movable hooks short, sharp, slender. Prothorax nearly as broad as head. Stigmata large, quite uncovered. Legs at base widely and equally separated; formed for running. Hind legs shorter than the body. Tarsi 3-jointed. Abdomen cylindrical above, flattened below, tapering at end like a sphinx pupa. Segments nearly equal in length, anal appendices rather long, pyramidal, sharp.

15. *Cordulegaster Sayi*.

SELYS, Synopsis des Gomphines, p. 85, No. 106; second additions, p. 40. Monogr. des Gomph. p. 331, No. 109. — *C. lateralis* Scudd., Proc. Boston S. N. H., X. p. 211.

Plate III., fig. 2.

Locality: Maryland; Cambridge and Chicopee, Mass. July 1–4, 1860. R. H. Wheatland. Length, 40 mm.

Head short, broad. Breadth twice the length, sides straight, rounded off behind so that the hind-border in front of prothorax is half the width of fore-border. Vertex flat. Hind-border somewhat indented. Eyes small, round, prominent, placed at forward lateral angles of fore border of head, with triangular piece projecting inward. Ocelli visible, especially the lateral ones. Antennæ 7-jointed, tapering, slender; the 2 basal joints thicker and more rounded, 3d longer than 2d; joints 3 to 7 form a rather slender seta. Mask large, extending a little beyond the middle legs, triangular, contracted behind; the sides bent up, hollowed back of fore-border, which is prolonged into a bifid tip, surmounted by a short hairy comb. Palpus broad, enlarged at inner border, and deeply denticulated, the denticulations of the opposite palpi closely fitting into one another; movable hook short, sharp, and slender. Prothorax half the length of head, and two thirds the breadth, indented in the middle, raised at fore part in small transverse lobe, at hind part border raised, and thicker in the middle. Stigmata large, open. Legs very hairy, flattened, formed for running. Femora angular, thick, and a little bent; tibiæ about equal in length to femora. Tarsi 3-jointed, more than half as long as tibiæ, 1st joint short, 3d longest; claws very sharp. Hind legs reaching the 7th segment. Abdomen long, rounded above, tapering gradually. Largest part at middle, as wide as head; no dorsal hooks. Segments 8 and 9 with lateral spines. Segments of about equal length. 3 anal appendices of twice length of 10th segment, pyramidal, sharp; superior somewhat shorter; lateral ones very short and sharp. At the end of 8th ventral segment a bifid triangular vulva nearly equal in length to 9th segment.

Have seen one not full-grown female nymph, length 30 mil., from Maryland, which is figured. Coll. Hag., and two full grown from Chicopee, Mass., length 40 mm. Coll. Mus. Comp. Zoöl.

It was thought best to refer this nymph to *C. Sayi*, as this is the only North American species very similar to *C. annulatus*.

16. Cordulegaster annulatus.

SELYS, Monogr. des Gomph., p. 333, No. 110.

Plate III., fig. 3.

Nympha, female, not full grown. Coll. Hagen. Locality, Lüneburg, Hannover; Mr. Heyer. Length, 30 mm.

Not to be distinguished from *C. Sayi*, but distinguished from *C. bidentatus* by having lateral spines on 8th and 9th segments, and by the length of superior anal appendix, which is, as in *C. Sayi*, of nearly equal length with lateral appendices. As the only species of *Cordulegaster* known in Europe are *C. bidentatus* and *C. annulatus*, this nympha is referred to the latter; *C. bidentatus* has not been found in the North of Germany.

17. Cordulegaster bidentatus.

SELYS, Monogr. des Gomph., p. 339, No. 112.

Plate III., fig. 1, a, b, c, d.

Nympha, female. Raised by Dr. Brauer. Locality, Vienna, Austria. Coll. Hagen. Length, 43 mm.

In most respects strikingly like *C. Sayi*; differs in having the sides of the head more straight, and less gradually sloped backward, making hind-border broader than *C. Sayi*; in having no lateral spines, and in the inferior length of superior anal appendix, which is one half the length of lateral appendices and blunt.

The figured specimen is described at some length by Dr. Hagen, in the *Stettin Entom. Zeit.*, XIV. p. 265, and by Dr. Brauer, *Neur. Austr.*, p. xv.

SYNOPSIS OF THE SPECIES DESCRIBED.

SUB-FAMILY: **GOMPHINA.**

SELYS, Monogr. des Gomph., p. 6.

DIVISION I. **INTÉGRILABIÉES.** SELYS, Monogr. des Gomph., p. 6.

The under lip entire in the imago.

Head cordate; eyes in the middle of the lateral border of the head; antennæ, 4 articulated, 3d flat, dilated, 4th rudimentary; mask not covering the mouth, nor the upper lip. Legs not equally distant at base; burrowing legs, at least the fore and middle legs; tarsus 2 articulated in the fore and middle legs, 3 articulated in the hind legs, or 2 articulated (Lindenia). Abdomen flattened.

LEGIO I. **Gomphus.** SELYS, Monogr. des Gomph., p. 6.

Mask reaching the fore legs, quadrangular, somewhat longer than broad; palpus hooked at the tip, inside, or denticulated, or with molar incisions. Hind legs farther distant at base than the fore and middle legs, which are equally distant and fitted for burrowing. Abdomen lanceolate.

A. *Front border of the mask produced at middle third in a rounded lobe not cleft.*

Sub-genus: **Herpetogomphus.** SELYS, l. c., p. 69. (Supposition.)

1. **H. species.** Nympha, full grown and larva. Brazil, Rio dos Macacos.

Mask, breadth half the length, having two small black teeth on each side of middle of the front-border; palpus finely denticulated. Abdomen gradually narrowing to tip. Segments 2 to 9 with dorsal hooks; lateral spines on 7 to 9; segment 10 a little longer than 9; anal appendices as long as segment 10, the superior a little shorter; the lateral ones half as long as the inferiors.

Sub-genus: **Gomphus.** SELYS, l. c., p. 118.

2. **G. pilipes** (or a related species; supposition). SELYS, l. c., p. 148.

Nympha, full-grown female. South Carolina, U. S. Mask nearly square; end hook of palpus not longer than the denticulations. Abdomen flat. Segments 9 and 10 very contracted; no dorsal hooks; lateral spines on 8th and 9th segments; segment 10 half as long as 9; anal appendices very short, nearly of equal length, the lateral ones a little shorter.

3. **G. vulgatissimus**, LINNÉ. SELYS, l. c. p. 129.

Nympha, full-grown female and male. Europe. Raised by Dr. F. Brauer. Mask quadrangular, front-border middle third finely denticulated; palpus finely denticulated at basal half. Abdomen flat; no dorsal hooks; lateral spines on segments 6 to 9; anal appendices a little longer as 10th segment, the lateral ones a little shorter; lateral spines of 9th segment half as long as 10th segment.

4. **G. fraternus** (or **vastus**, or **fluviatilis**, or **annicola** WALSH, supposition).

Nympha. Rock Island, Ill. Similar to **G. vulgatissimus**. Segments 8 and 9 with dorsal tubercles; lateral spines of segment 9 longer than segment 10.

5. **G. species.**

Nympha, full grown. Massachusetts. Similar to **G. vulgatissimus**. Spots instead of tubercles on occiput; dorsal hooks but little developed on segments 6 to 9; lateral spines on 7 to 9; segment 9 longer than 8, with lateral spines half as long as segment 10.

6. G. species.

Nympha. Pole Creek, Texas. Mask quadrangular, front border of the middle third finely denticulated; palpi blunt, very finely denticulated; abdomen with dorsal hooks on 2d to 9th; lateral spines on 7th to 9th; the lateral spines of segment 9 much shorter than segment 10; anal appendices longer than segment 10, sharp, of nearly equal length.

B. *Front border of the mask produced at middle third in a cleft lobe.*

Sub-genus: **Cyclogomphus**. SELYS, l. c., p. 105. (Supposition.)

7. G. Species.

Nympha, full grown. Himalaya, Ghugger Pir. Body flat; mask quadrangular, front-border produced at middle third in elliptical lobe, cleft in the middle, with comb of bristles thickened at base; palpus with molar incisions to the end hook. Abdomen flat; no dorsal hooks; lateral spines on 5th to 9th; lateral spine of segment 9 half as long as segment 10; anal appendices a little longer than segment 10, of equal length, sharp.

C. *Front border of the mask cut straight.*

Sub-genus: **Macrogomphus**. SELYS, l. c., p. 87. (Raised.)

8. M. spiniceps WALSH. Proc. N. H. Soc., Phila., 1862, p. 889.

Nympha, full-grown male and female. Lawrence, Mass. Raised by Mr. Fr. G. Sanborn. Body long, narrow; mask quadrangular, front border cut straight. Abdomen somewhat conical, tapering; segment 9th twice as long as the foregoing, narrowed in the middle; no dorsal hooks; segment 6 to 9 with lateral spines; anal appendices as long as the 10th segment, which is short and slender, of equal length, pyramidal.

LEGIO II. Gomphoides. SELYS, l. c., p. 189.

The general character is not yet given, all species, except one, determined merely by supposition, the determination of some doubtful.

A. *Antennæ with the third joint long, the fourth $\frac{1}{4}$ length of the third; middle legs nearer at base than fore legs.*

Sub-genus: **Progomphus?** SELYS, l. c., p. 194. (Supposition.)

9. Progomphus species!

Nympha, full-grown male and female. Wareham, Mass.; Carundahy, Brazil. There is no genus known to be living in both countries; Progomphus lives in Brazil, though the locality, Massachusetts, is doubtless correct. If the determination is erroneous, as is possible, no other seems more probable.

Body lanceolate; antennæ, 3d joint long, dilated; 4th small, cylindrical, $\frac{1}{4}$ length of 3d; mask reaching fore legs, long, front-border produced in semicircular lobe, with a comb of flattened hairs; palpi blunt, smooth inside; middle legs nearer at base than fore legs; tarsi knife-shaped, bent up. Abdomen flattened; segments 1 to 9 with dorsal hooks; segments 5 to 9 with lateral spines; anal appendices of equal length, sharp; the lateral ones half as long, blunt.

B. *Antennæ with the third joint long, the fourth very short, linear; middle legs and fore legs equally distant; segment 10 very elongated.*

Sub-genus: **Gomphoides**. SELYS, l. c., p. 206. (Supposition.)

10 Gomphoides species.

Nympha, male. Sta Cruz, Brazil. Body long, slender; antennæ 3d joint long, dilated; 4th short, linear; mask a little beyond fore legs, long; front border middle third produced in semicircular lobe; palpi hooked at tip, smooth inside; middle legs and fore legs equally distant at base; tarsi knife-shaped. Abdomen long, conical; segment 10 exceedingly long, cylindrical; segment 4 to 6 with small dorsal hooks; lateral spines on segment 7 to 9; anal appendices very short, all of equal length. (An **Aphylla brevipes** SELYS?)

11. Gomphoides species.

Nympha, female, not full grown. Rio dos Macacos, Brazil. Very similar to the foregoing; dorsal hooks on segments 4 to 9. Perhaps a sexual difference?

C. Antennæ 3d joint enlarged, circular; body very flat, circular; segment 10 entirely inserted in the 9th.

Genus : **Hagenius**. SELYS, l. c., p. 238.

12. **Hagenius brevistylus**. SELYS, l. c., p. 241. Raised by T. W. Harris.

Nympha, female, full grown and young. U. S. Body very flat, enlarged; antennæ 3d joint very flat, circular; 4th rudimentary; mask reaching the fore legs, square, front-border somewhat produced; palpi blunt, smooth inside; fore legs nearer at base than middle legs. Abdomen nearly circular; dorsal hooks and lateral spines on segment 2 to 9; segment 10 very small, inserted in 9; anal appendices short, the lateral ones very small.

13. **Hagenius Japonicus**. SELYS, l. c., p. 244. (Supposition.)

Nympha, male. Kanagawa, Japan. Similar to the foregoing. Abdomen straighter at sides; dorsal hooks flattened; superior anal appendix not so deeply channelled at sides.

LEGIO III. **Lindenia**. SELYS, l. c., p. 246.

Sub-genus : **Ictinus**. SELYS, l. c., p. 263. (Supposition.)

14. **Ictinus species**. Doubtful determination.

Nympha, male and female. Himalaya, East Indies. Body short, roof-shaped; antennæ 3d joint elongated, 4th rudimentary; mask extending between the fore legs, square, front-border nearly straight; palpi rather blunt, inside finely denticulated; hind legs more distant at base; tarsi of all, 2 articulated. Abdomen ovoid, side-border sharp, denticulated in the males in segment 7 to 9; lateral spines and dorsal hooks in segment 2 to 9; segment 10 very small, inserted in 9; anal appendices short, sharp, the lateral ones a little shorter.

DIVISION II. **FISSILABIËES**. SELYS, l. c., p. 303.

The under lip cleft in the imago.

LEGIO IV. **Chlorogomphus**. SELYS, l. c., p. 311. Unknown.

LEGIO V. **Cordulegaster**. SELYS, l. c., p. 317. (Raised.)

Head transverse, oblong; eyes in the fore corners; antennæ, 7 articulated, filiform; mask extending beyond the middle legs, spoon-shaped, covering the mouth and the upper lip; legs widely and equally separated; tarsi 3 articulated; abdomen more cylindrical, tapering to the tip; the posterior suture of the segments somewhat elevated; anal appendices pyramidal.

15. **Cordulegaster Sayi**. SELYS, l. c., p. 331. (Supposition.)

Nympha, full-grown female. Chicopee and Cambridge, Massachusetts; Maryland. Tip of the mask bifid; dentation of the palpus sharp; lateral spines on segments 8 and 9; superior anal appendix nearly as long and sharp as the inferiors; lateral ones very short.

16. **Cordulegaster bidentatus**. SELYS, l. c., p. 339. (Raised by Dr. Brauer.)

Nympha, female, full grown. Europe, Vienna. Very similar to the foregoing; head more straight; no lateral spines; superior anal appendix half as long as the inferior, blunt at the tip.

17. **Cordulegaster annulatus**. SELYS, l. c., p. 333. (Supposition.)

Nympha, female, not full grown. Europe, Lüneburg. Not to be distinguished from *C. Sayi*.

LEGIO VI. **Petalura**. SELYS, l. c., p. 362. Unknown.

EXPLANATION OF THE PLATES.

PLATE I.

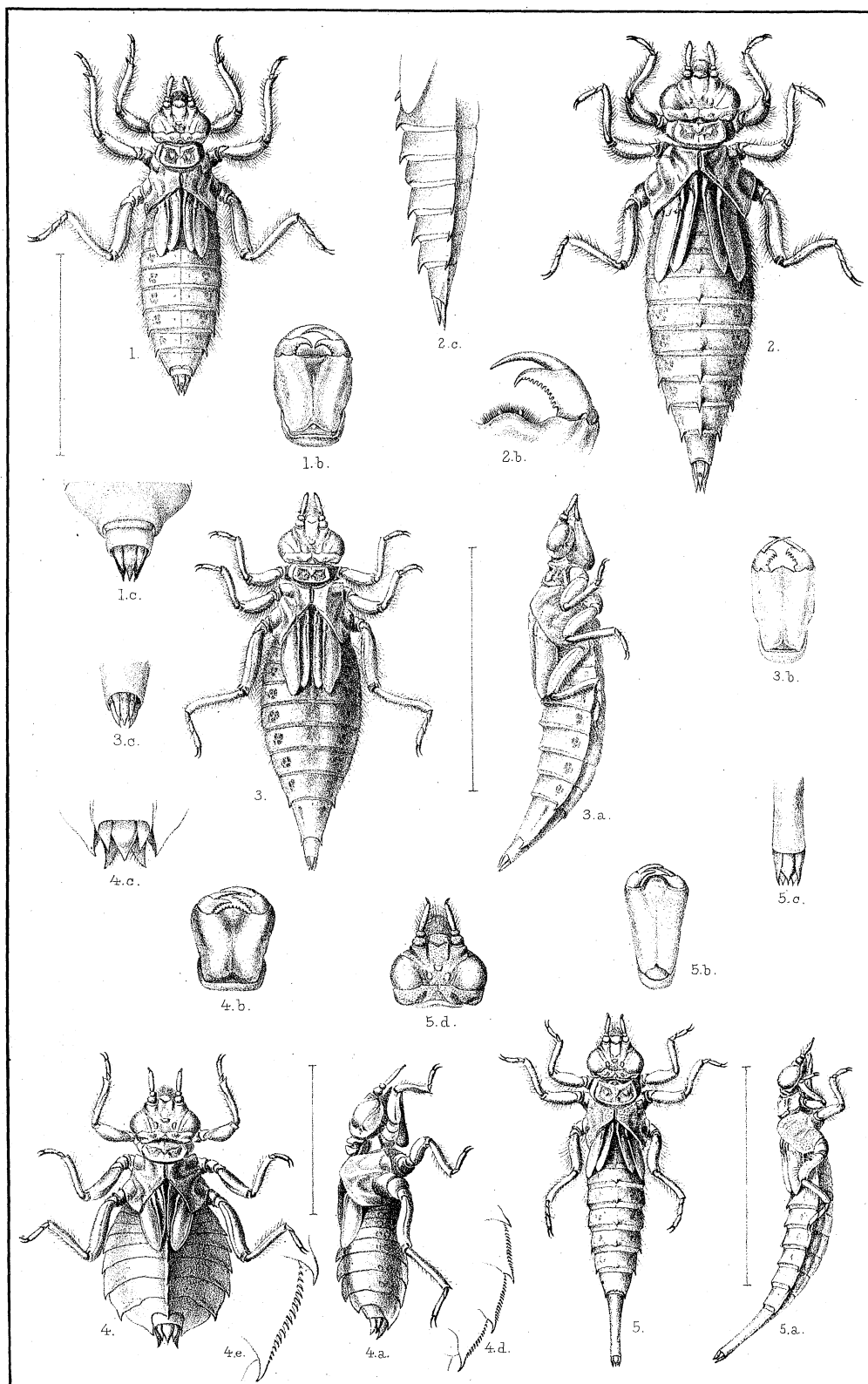
- Fig. 1. *Gomphus vulgatissimus*; *b*, labium; *c*, appendices.
“ 2. *Herpetogomphus*; *b*, labium; *c*, side view.
“ 3. *Gomphus pilipes*? *a*, side view; *b*, labium; *c*, appendices.
“ 4. *Ictinus*; *a*, side view; *b*, labium; *c*, appendices; *d*, lateral border of the abdomen; *e*, the same (the tip) more magnified.
“ 5. *Gomphoides*, species No. 10; *a*, side view; *b*, labium; *c*, appendices; *d*, head.

PLATE II.

- Fig. 1. *Macrogomphus spiniceps*; *a*, side view; *b*, head; *c*, two last joints of the antenna.
“ 2. *Gomphus*, species No. 7; *b*, labium; *c*, the same (the tip) more magnified; *d*, bristles of the labium border.
“ 3. *Progomphus*? *a*, side view; *b*, labium; *c*, bristles of the labium border.
“ 4. *Gomphus*, species No. 4; *b*, labium.
“ 5. *Gomphus*, species No. 5.
“ 6. *Gomphus*, species No. 6; *b*, labium.

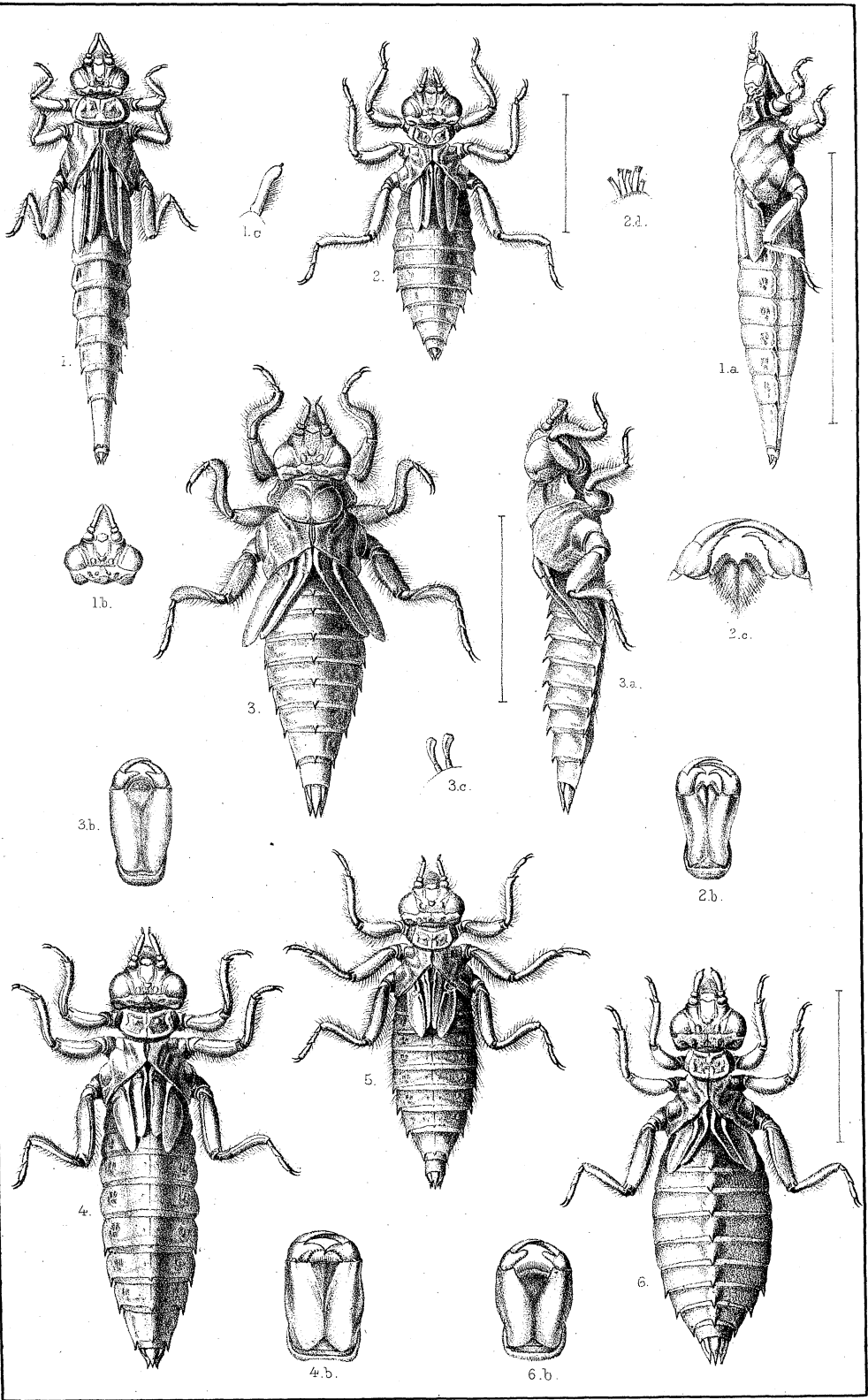
PLATE III.

- Fig. 1. *Cordulegaster bidentatus*; *a*, side view; *b*, labium; *c*, head; *d*, bifid tip of the labium.
“ 2. *Cordulegaster Sayi*.
“ 3. *Cordulegaster annulatus*; *b*, appendices.
“ 4. *Hagenius brevistylus*: *a*, side view; *c*, head; *d*, wing-cover.
“ 5. *Hagenius Japonicus*; *c*, head.



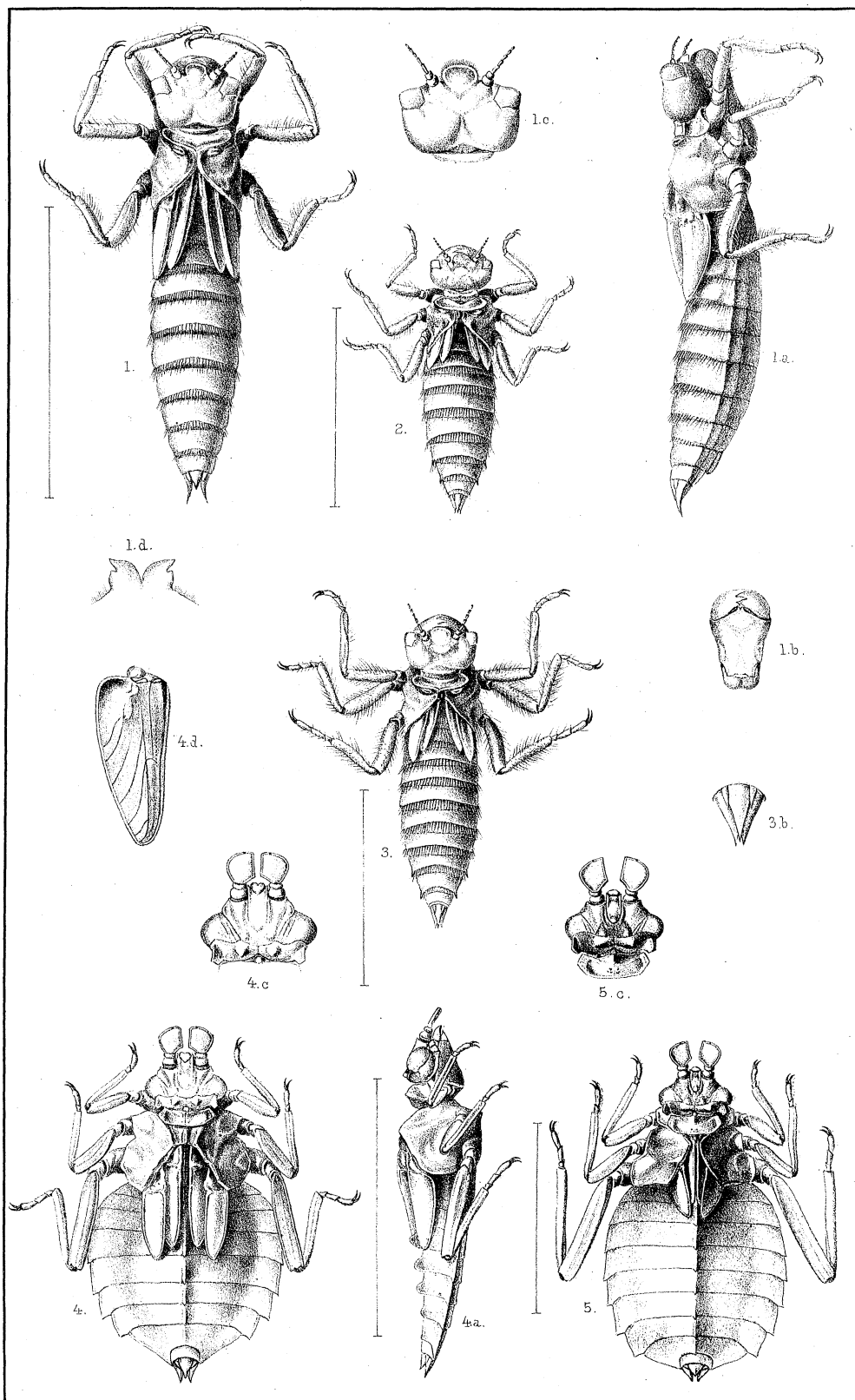
L.Gabes del. F.Konopalsky lith.

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ILLUSTRATED CATALOGUE
OF THE
MUSEUM OF COMPARATIVE ZOÖLOGY,
AT HARVARD COLLEGE.

No. VI.

SUPPLEMENT TO THE OPHIURIDÆ AND ASTROPHYTIDÆ.

BY
THEODORE LYMAN.

CAMBRIDGE:
PRINTED FOR THE MUSEUM OF COMPARATIVE ZOÖLOGY.
1871.

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CAMBRIDGE.

E R R A T A .

IN No. I.

Page	9,	5th line from bottom,	<i>for</i> Berthelet	<i>read</i> Berthelot.
"	10,	13th " " "	" abyssicola	" abyssiculum.
"	12,	5th " " top,	" isocanthum	" isacanthum.
"	14,	22d " " "	" Asterochema	" Asteroschema.
"	105,	15th " " "	" Five arms	" Five or six arms.
"	118,	12th, 14th lines from top,	" innermost	" outermost.
"	197,	5th line from top, right column	" Asterochema	" Asteroschema.
"	" 7th	" " " " " "	" Asteromyx	" Asteronyx.
"	198,	36th, 37th line from top, left column	" 52	" 152.

IN No. VI.

Page	7,	48th line from top	<i>for</i> grandisquania	<i>read</i> grandisquama.
"	8,	10th " " "	" bevispina	" brevispina.
"	8,	30th " " "	" Michlin	" Michelin.
"	(18)	Description Plates, figs. 1 - 6	" Ophyoglypha	" Ophioglypha.

IN the six years that have passed since the publication of the first number of this Catalogue, which treated of Ophiuridæ and Astrophytidæ, our knowledge of these families has considerably increased. Many new species have been discovered, among which the singular forms, brought up by the deep-sea dredgings off Florida, and described in Bulletin No. 10, Vol. I., are of particular interest. In the present Supplement to the Catalogue, figures are given of the most important of these deep-sea Ophiurans; and there are added descriptions of one new genus and of five new species from shallow water. There are given, also, lists of the principal authors, and of the new species described by them, since 1865, making a continuation of similar lists published in Catalogue No. I.

LOUIS AGASSIZ.

October 10, 1871.

PRINCIPAL AUTHORS

SINCE THE PUBLICATION OF CATALOGUE No. I., IN MARCH, 1865.

To which are added some publications not before included. The new species are mentioned with each author.

- BRADY & ROBERTSON. Ann. and Magazine of Nat. Hist., III. p. 355.
A notice of *Ophianoplus annulosus*, Sars, from W. Coast of Ireland.
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Ophioderma variegata. (= *O. brevicauda* Ltk. ?)
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Ophiolepis annulosa. M. T. (No such thing there.)
" trisquamosa.
" vicina.
" albida.
" Tancredi.
Ophiocoma scolopendrina. M. T. (No such thing there.)
" serpentaria. M. T. (= *O. echinata* Agass.)
" crassispina. M. T. (= " " "
" punctata (= *O. pumila* Ltk. ?)
Ophiarachna gorgonia. M. T. (No such thing there.)
Ophiothrix fragilis. M. T. (No such thing there.)
" quinquefissa. (= *O. orstedii* Ltk. ?)
Ophiura hexactinia. Lmk. (No such thing there.)
Euryale costosum. } (= *Astrophyton costosum* Seba. ?)
" muricatum. }
- Trichaster** Isidis (= *Asteropora*, Ltk. ? vel *Astrogomphus* Lym. ?)
- I never saw this little pamphlet till recently, and it seems also to have escaped Dr. Lütken's notice. It antedates his descriptions of West Indian Ophiurans by several years ; but the short Latin descriptions are so incomprehensible and so vague that I do not think they can be accepted as a basis for priority.
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Ophiothrix alopecurus. M. T. He considers different from *O. fragilis*. p. 63.
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Colored drawings of *Ophiomastix annulosa*, *Ophiolepis annulosa*, *Ophioplocus imbricatus*, *Ophiocoma picta*, *Ophiarachna incrassata*, *Ophiothrix longipeda*, *Ophiothrix serrata*, K. & v. Has. Good colors, but no details.

LJUNGMAN, AXEL. Om några nya arter af Ophiurider. Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar. 1866. No. 6.

Ophiogymna. Gen. nov.

Ophiogymna elegans. Singapore, Hong Kong. p. 163.

Ophiothrix clypeata. Singapore. p. 163.

Ophiactis megellanica. Straits of Magellan. p. 164.

“ *fragilis.* Hawai. p. 164.

Ophiophragmus Loveni. Rio Janeiro. p. 165.

Amphipholis. Gen. nov. (*Amphiuræ* pars.) p. 165. See Bulletin Mus. Comp. Zoöl., No. 10, Vol. I. p. 335.

Amphipholis Januarii. Rio Janeiro. p. 165.

Ophioglypha Kinbergi. Sidney, N. H. p. 166.

Ophiuroidea Viventia huc usque cognita. Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar. 1866. No. 9.

Ophiarachna stellata. Singapore. p. 305.

“ *spinosa.* (= *Ophiopeza fallax*? See Ltk. Addit. III. 36.) Foua Is. p. 305.

Ophioglypha multispina. Sidney. p. 307.

“ *Tenori.* Mediterranean (*Ophiura*, Delle Chiaje). p. 308.

Ophiopus. Gen. nov.

“ *arcticus.* Spitzbergen. p. 309.

Ophionereis squamata. Honolulu. p. 310.

“ *crassispina.* Honolulu. p. 311. (See Bulletin Mus. Comp. Zoöl., Vol. I., No. 10, p. 312, note.)

Amphipholis (vel *Amphiura*) *depressa.* Deep sea between Batavia and Singapore. p. 312.

“ “ “ *integra.* Port Natal, S. Af. p. 313.

“ “ “ *bastata.* Mozambique. p. 313.

“ “ “ *grisea.* Gulf of Guayaquil. p. 313.

“ “ “ *impressa.* Deep sea between Batavia and Singapore. p. 314.

“ “ “ *albida.* (= *A. Januarii*?) Rio Janeiro. p. 314.

“ “ “ *subtilis.* (= *A. Januarii*?) Rio Janeiro. p. 314.

“ “ “ *lobata.* Near Sidney, N. H. p. 314.

Ophiophragmus antarcticus. “In fretu Magalhaënsi.” p. 315.

“ *gibbosus.* Port Natal, S. Af. p. 316.

“ *echinatus.* Sea between Batavia and Singapore. p. 316.

Amphiura divaricata. Deep sea between Batavia and Singapore. p. 318.

“ *Eugeniæ.* Atlantic, opposite river La Plata. p. 318.

“ *candida.* Near Mozambique. p. 318.

“ *complanata.* Atlantic, off Rio Janeiro. p. 319.

“ *crassipes.* “ “ “ p. 319.

“ *flexuosa.* Near Brazil. p. 319

“ *verticillata.* Galapagos Islands. p. 320.

“ *capensis.* Near Port Natal and Cape of Good Hope. p. 320.

“ *magellanica.* Straits of Magellan. p. 320.

“ *latispina.* Atlantic, off river La Plata. p. 320.

“ *atlantica.* Near St. Helena. p. 321.

Ophiocentrus. Gen. nov.

“ *aculeatus.* Deep sea between Batavia and Singapore. p. 321.

Amphilepis. Gen. nov.

“ *norvegica.* Norway. p. 322.

Hemipholis affinis (*H. gracilis* Vll.) Guayaquil. p. 322.

Ophiactis (?) *Savignyi* (*Ophiolepis* M. T.) Egypt. p. 323.

“ *carnea.* Port Natal, S. Af. p. 324.

Ophiacantha indica. Deep sea between Batavia and Singapore. p. 326.

Ophioscolex purpurea. Düben and Koren, Norway. p. 327.

Ophiocnemis obscura. Straits of Malacca. p. 333.

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Amphiura tenuispina. (= *Amphiura squamata*, var.?) p. 360.

“ *norvegica.* Norway. p. 363.

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Amphipholis fissa. Amur. p. 98.
Ophiocoonis. Gen. nov. (= *Pectinura* Heller.) (O. Forbesii.) p. 98.
Ophiopsammus. Gen. nov. (= *Ohiopeza* Yoldii.) p. 98.
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" *asperula*. Feejee Islands. p. 99.
" *caryophyllata*. Feejee Islands. p. 99.
Ophiomyxa australis. Between Australia and Tasmania. p. 99.
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Ophiacantha pentacrinus. (= *O. meridionalis* Lym.) W. Indies, deep sea. p. 99.
Ophiothrix striolata. Grube. New Guinea and China Sea. p. 99.
" *elegans*. China Sea. p. 100.
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Ophiomusium eburneum. (Illustr. Cat., No. VI., Pl. II., figs. 1, 2, 3.) p. 322.
Ophiacantha pentacrinus Ltk. (= *O. meridionalis* Lym.) p. 324.
Ophiomitra. Gen. nov.
Ophiomitra valida. (Illustr. Cat., No. VI., Pl. II., figs. 4, 5, 6.) p. 325.
" *sertata*. p. 326.
Ophiochondrus. Gen. nov.
Ophiochondrus convolutus. (Illustr. Cat., No. VI., Pl. II., fig. 7.) p. 328.
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" *plana*. p. 330.
" *loricata*. p. 331.
Amphiura semiermis. p. 332.
" *grandisquania*. p. 334.
" *pulchella*. p. 337.
Ophiocnida olivacea. (Illustr. Cat., No. VI., Pl. I., fig. 7, 8.) p. 340.
Ophiothamnus. Gen. nov.
Ophiothamnus vicarius. (Illustr. Cat., No. VI., Pl. II., figs. 8, 9.) p. 342.
Ophiomyces. Gen. nov.
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DESCRIPTION OF NEW SPECIES.

OPHIOMAZA.* GEN. NOV.

Teeth. Tooth-papillæ numerous, and arranged in a close vertical oval, as in *Ophiothrix*. No mouth-papillæ. Disk below naked, but covered above with large, swollen radial-shields and plates. Arm-spines stout, nearly smooth, as in *Ophiocoma*.

This curious genus has the dentition of *Ophiothrix*, the disk of *Ophiocnemis*, and the arms of *Ophiocoma*.

Ophiomaza cacaotica. SP. NOV.

Plate I., fig. 15.

Special Marks.—Five, sometimes six arm-spines, the two or three upper ones considerably largest. No tentacle-scale. Interbrachial plates on back of disk elongated and irregularly broken.

Description of a Specimen.—Diameter of disk, 11^{mm}; from outer side of mouth-shield to outer corner of opposite mouth-slit, 4.2^{mm}; distance from outer side of mouth-shield to inner points of tooth-papillæ, compared to that between outer corners of mouth-slits, 2.5 : 2. Width of arm, 2^{mm}; length of arm about 30^{mm}; tooth-papillæ small and crowded, about 26 to each angle of the mouth; four strong, square-edged teeth. Under arm-plates, beyond edge of disk, broader than long; their laterals and inner side slightly re-enteringly curved; outer side slightly curved; length to breadth (6th plate), 9 : 1.2. Within the disk there are six plates, of which the one next the mouth-slit is small and oval; those outside of it grow gradually broader and are shaped like those beyond the disk; side arm-plates stout, but not much projecting; upper arm-plates broader than long, somewhat irregular, broader without than within, outer side curved; length to breadth (8th plate), .9 : 1.6. The first two or three plates are narrow and wedge-shaped and fit in a notch in the disk; beyond the margin they grow wider, and have their

* ὄφης, serpent; μάζα, a cake.

full width at the 7th or 8th plate; disk naked below and covered by thick, wrinkled skin; radial shields very large, pear-seed shape, length, to breadth, 4:2.5, separated by a band of three or four elongated, narrow, broken, and irregular plates, which come to the edge of the disk, and are continuous with the upper arm-plates. Interbrachial spaces covered by plates similar in form to those between radial-shields, but wider; in the centre, a rosette of small, very irregular pieces, one in the middle, and five close around it. The edge of the disk has a row of stout, swollen plates, three to five in each interbrachial space, of which one is opposite the radial-shield on either side, and from one to three are opposite the interbrachial plates. Arm-spines usually five sometimes six; the two or three upper ones much the longest; all stout, tapering, blunt, cylindrical; lengths, to that of the upper arm-plate (7th joint), 2.2, 2, 1.6, 1, 1, .5:.9. Near end of arm, three or four spines, of which the under one is much swollen at the base, and slightly hooked at the end. Color, in alcohol: deep chocolate. Zanzibar, collected by Mr. Cooke.

Ophiothela tigris. Sp. nov.

Plate I., figs. 10, 11, 12.

Special Marks.—Back of disk completely covered by the radial-shields, which are quite smooth, as are also the interbrachial spaces below. Five arms.

Description of a Specimen.—Diameter of disk, 7^{mm}.; length of arm (which had been repaired), 12^{mm}.; from outer corner of mouth-slit to outer edge of opposite mouth-shield, 3^{mm}.; width of arm, including side arm-plates, 2^{mm}.; distance from outer corner of mouth-shield to points of tooth-papillæ, to that between outer corners of mouth-slits, 1.6:1.5. Tooth-papillæ arranged in a close, vertical, oval clump; about fifteen in number; four stout, flattened, squarish teeth, which with the tooth-papillæ form a dentition like that in *Ophiothrix* (a generic character); mouth-shields irregular, sometimes in form only of a small swelling; but, when clearly defined, having an oval heart-shape, with outer side straight, and with length to breadth, .5:1. Side mouth-shields large and conspicuous; their free lateral sides re-enteringly curved; their inner laterals joined along their whole length; their inner sides making together a wide curve; under arm-plates covered with thick skin and seen indistinctly, except when dry. They have an irregular triangular form, with a peak within and a lumpy surface. They cover only a part of the arm, and differ in figure one from another. Side arm-plates

standing out independently, as pad-like ridges (a generic character), which are stout and swelled; upper arm-plates represented by a double row of irregular elongated warts, which just at the base of the arm are increased in number, so as to form a clump of different-sized pieces. At the tapering end of the arm there are still the two warts at the base of each joint, and between these a double row of fine grains. Disk wholly covered above by the ten great radial shields, which are regular, slightly swelled, and smooth; at the insertion of the arm and in the interbrachial space they form a slight notch or re-entering angle. Interbrachial spaces below covered with thick skin, without spines or scales; genital-slits with a large prominent scale at their outer end, whose edge can be seen from above. Arm-spines like little stumps, thorny at their ends; towards the end of the arm they become more flattened, and the three lowest ones are armed with three or four flattened hooks. The first joint outside the mouth-shield has two or three spines on each side; the second three, and the rest four. Color, in alcohol: upper surface lined and marbled with dark green and light yellow, interbrachial spaces below dark green; under surface light greenish.

Another specimen had a disk of 5.5^{mm}, and arms of 18^{mm}. The mouth-shields were all regular, except the madreporic, which was swelled. The back of the disk had a central pentagon of marbled bluish and yellow, surrounded by a band of yellowish. The animal doubtless has the power of *moving* the side arm-plates, which in this specimen were folded close on the arm.

Locality unknown, but supposed to have been brought from the Pacific by the Exploring Expedition.

Ophiocnida Putnami.* SP. NOV.

Plate I., fig. 9.

Special Marks.—Nine or ten flat arm-spines, the upper ones with broad ends; they closely cover the arm, as if with grains of rice regularly set in rows. Disk beset with similar, but smaller spines. Two swelled papillæ at the apex of the mouth-angle. Two tentacle-scales.

Description of the Specimen.—Diameter of disk, 16^{mm}. Width of arm, 2.5^{mm}; length of arm about 72^{mm}. From outer side of mouth-shield to outer corner of opposite mouth-slit, 4.8^{mm}; distance from outer corner

* Named after the late Captain W. H. A. Putnam, a man of a fine taste in natural history, and who enriched this Museum with remarkable collections made during his sea voyages.

of mouth-slit to inner point of mouth-papillæ, to that between outer corners of mouth-slits, 2.2 : 2.4 ; mouth-shields small, rounded, narrower without, length to breadth, 1.1 : .8 ; side mouth-shields small and not meeting within ; two large swelled mouth-papillæ at the inner apex of the angle ; they are pressed close together and present a re-entering grinding surface ; above, and partly covered by them, a swollen irregular tooth, followed by three more which are squeezed together and more or less thickened ; above these again are four flat, square-edged teeth separated from each other, the uppermost are longest. Outside each mouth-papilla stands the thick, club-like tentacle-scale of the first mouth-tentacle ; above which, and nearly hidden in the mouth-slit, is the tooth-like scale of the second mouth-tentacle. Under arm-plates small, nearly square, with slightly re-entering sides ; length to breadth (9th plate), .8 : .8. Upper arm-plates small, nearly round, but farther out on the arm, the inner side is straight ; length to breadth (12th plate), .8 : .9. Arm-spines 9 (near base of arm 10), white, flattened, upper ones broadened towards the end, like a narrow spatula ; lowest one broadest and stoutest, next two or three above it narrower than the rest ; length of uppermost, .8^{mm}. ; 7th, 1.2^{mm}. ; lowest, 1^{mm}. towards point of arm, 5 or 6 spines which are flat and taper to a blunt point. No tentacle-scales ; tentacles large and long. Disk puffy and lobed, covered above and below with fine, regular scales, about 60 to a square ^{mm}. ; beset above and below with numerous stout, flattened, spines, .8^{mm}. long, and resembling the arm-spines. Radial-shields small, inclining to crescent-shape, separated and standing just over base of arm ; length to breadth, 2.6 : 1. Color, in alcohol : disk gray ; arms straw color.

Collected, almost without doubt, at Hong Kong, by Captain W. H. A. Putnam.

This handsome species is an *Amphiura* with a thorny disk ; and I therefore place it in *Ophiocnida*, as an approximation to its natural position, without asserting that its affinities are thus exactly expressed. See Bulletin of the Mus. Comp. Zoöl., Vol. I. p. 335.

Ophioglypha sinensis. SP. NOV.

Plate I., figs. 1, 2.

Special Marks. — A pit or depression between the side arm-plates, on the under side of the joints within the disk (as in *O. lacertosa*). Only one tentacle-scale on most of the pores beyond the disk. An arm-comb along the edge of the radial-scale, but none on the arm itself.

Description of a Specimen. — Diameter of disk, 9^{mm} ; from outer corner of mouth-slit to outer side of opposite mouth-shield, 4.2^{mm} ; distance from outer side of mouth-shield to point of innermost mouth-papilla, to that between outer corners of mouth-slits, $2:2$; width of arm, 1.4^{mm} . Mouth-papillæ, six to each angle, whereof the two outer ones on each side are thin and triangular, and the innermost is stouter and more elongated, approaching the form of the teeth, which are four in number, stout, and formed like a blunt spear-head. Mouth-shields large, "lyre-shaped," that is to say, bounded by a curve without, an angle within, and by re-entering curves on the sides; so that the inner corners, at the heads of the genital-slits, make little peaks; length to breadth, $1.7:1$. Side mouth-shields very narrow, meeting within, and running along inner angle of mouth-shield to its corner, where they run across the head of the genital-slit to the side arm-plate. Under arm-plates small, much wider than long, with an angle within and a curve without. This is their general form, except that the first two or three are squeezed laterally; length to breadth (8th plate), $.2:.5$, a little way out they become very minute. Side arm-plates large, meeting below along a line longer than the under arm-plate; those within the disk are indented at their juncture, making a little pit. They make a re-entering curve where the tentacle-scale is fixed, and at little peak between it and the under arm-plate. Upper arm-plates strongly arched, wider without than within; bounded by straight lines on the sides and by a curve without; length to breadth (8th plate), $.6:.8$. Disk covered with larger and smaller irregular scales, among which may be seen the larger, round, primary plates. Radial-shields pear-seed shape, nearly or quite touching without; length to breadth, $1.3:1$. Radial-scales carrying a close comb of rounded tapering papillæ, in form like the arm-spines, which grow smaller as they pass below the disk and end in a row of fine grains, midway the genital-slit. Arm-spines, three, slender, rounded, regularly tapering, not quite so long as the joint; length to that of under arm-plate (8th joint), $.8, .7, .7:.2$. Tentacle-scales thin and nearly round. On the first pair of great pores, three or four on each side; on the second and third, three on one side and two on the other; on the fourth, two on one side and one on the other. The next four or five pores have one large scale, and a very small one, which last stands on the side arm-plate. Color, in alcohol: straw yellow.

Collected, almost without doubt, at Hong Kong, by Captain W. H. A. Putnam.

Variations. — All the specimens had broken arms, but by their character they had probably about the proportions of *O. Sarsii*, say a length of three or four times the diameter of the disk. There were two specimens in which the side mouth-shields were broader; the pits on

the under side of the base of the arm, little marked or wanting, and no little peak in the under arm-plate next the tentacle-scale. Perhaps another species, perhaps only a variety.

O. sinensia looks a good deal like *O. lacertosa* of Europe, but is distinguished by wanting the additional comb of papillæ on the base of the arm, and in having fewer tentacle-scales.

Ophiomastix janualis. SP. NOV.

Plate I., figs. 13, 14.

Special Marks.—Disk-scales conspicuous below, but obscured by thick skin on the upper surface of disk, which is beset with sharp tapering spines; but none below. Three round tapering arm-spines, the uppermost longest.

Diameter of disk, 5.5^{mm.}; arm nearly cylindrical, 1.2^{mm.} wide; very slowly tapering to a length of 24^{mm.}, where it is broken off. From outer corner of mouth-slit to outer side of opposite mouth-shield, 2.5^{mm.}; distance from outer side of mouth-shield to inner points of tooth-papillæ, to that between outer corners of mouth-slits, 1.2 : 1.5. Tooth-papillæ four, arranged in a close clump, directly below the teeth, which are as in *Ophiocoma*. Mouth-papillæ, 8, arranged in a close half-circle round the mouth-angle; outer ones flat, rounded, as long as broad; inner ones narrower and smaller. Mouth-shields longer than broad, narrower within than without, angles rounded; length to breadth, .9 : .6. Side mouth-shields triangular, lying along the sides of the mouth-shields, but not meeting within. Under arm-plates wider without than within, with a little peak without, and their sides a little re-enteringly curved; length to breadth (6th joint), .6 : .5. Farther out, the plates become more elongated, with a clean curve without, re-entering sides, and a truncated angle within. Side arm-plates projecting but slightly; at base of arm they meet neither above nor below, but, at the 11th upper arm-plate, they meet above. Upper arm-plates wedge-shaped, with a curved outer side, and laterals re-enteringly curved; length to breadth (6th plate), .7 : .6. Disk finely scaled in the interbrachial spaces below, each about $\frac{1}{8}$ ^{mm.} long; above the scaling is covered except near the edge, round the radial-shields, and at the base of the arm, to which it extends. Scattered over the upper surface are a few sharp spines, 1.5^{mm.} long, which are mounted on slight elevations and stand over the places of the primary plates. The radial-shields project close to the arm as little, irregular, triangular, swellings about .7^{mm.} long. Arm-spines three, rounded, slightly tapering, blunt;

under a lens, finely grooved; lengths (5th joint), 2.3, 2, 1.2. Tentacle-scales usually two, of which the outer is nearly oval, the inner small, narrow, and tooth-like. Color, in alcohol: chocolate brown, dappled with yellowish.

Mexillones, Bolivia; Captain Putnam.

As to the genus of this specimen, it may be called a spiny *Ophiocoma*, or an *Ophiomastix* wanting the club-shaped arm-spine. Müller & Troschel, in characterizing *Ophiomastix*, say (Syst. Asterid., 107), "Disk beset with scattered spines. . . . On the arms, above the spines, club-shaped bodies running out at their ends into several projections"; and their original, *O. annulosa*, has a fine imbricated scaling, from which stand out little naked radial-shields. Lütken (Addit. ad Hist. Oph., Pt. III. p. 26) has shown that the club-shaped spine is not a constant feature in the genus, which therefore is hardly to be set off from *Ophiocoma*, and that, moreover, the disk may be beset either with spines of various sorts, or with spines and grains. With the addition of this species, his view of the genus would stand thus:—

A. Disk smooth or with very few short spines,	<i>O. venosa</i> Pet.
B. Disk closely beset with grains and moderately long spines,	<i>O. mixta</i> Ltk.
C. Disk densely beset with very short spines,	<i>O. asperula</i> Ltk.
D. Disk on both sides beset with long thin spines,	{ <i>O. annulosa</i> M. T.
E. Disk beset on its upper surface, only, with slender spines; arm-spines	{ <i>O. caryophyllata</i> Ltk.
all slender and tapering,	{ <i>O. janualis</i> Lym.

The species under A, B, C, and D all have certain of the arm-spines either club-shaped or forked at the end, but that under E has no thickening of these spines.

NOTE ON NOMENCLATURE AND CLASSIFICATION.

Dr. Lütken, in a foot-note on page 68 of his Additamenta (Part III.), remarks: 1. That names prior to Linnæus have no place in present nomenclature. 2. That, when an author has described a species, his name must always be put after that species as the authority, no matter if the *generic* name be *changed*. As to the first of these propositions, I may say, that Linnæus first contrived what is called binomial nomenclature, in which each animal has two names, the generic and the specific. Consistency is the first duty of a naturalist, therefore it was the first duty of the followers of Linnæus to respect and to adopt such binomial names as may be found in ante-Linnæan authors, of whom some were among the most celebrated of zoölogists. When, then, I find the name *Astrophyton costosum* distinctly used by Seba (III. Pl. IX., Fig. 1, p. 16, 1758), and moreover an excellent figure given, I shall certainly apply that name to the West Indian species to which it belongs. Did not

Seba, more than a century ago, publish a fine folio, with figures that are better than some of those we see nowadays, and shall we ignore his names when they are such as may properly be taken? In putting such a name as *Ophiopholis bellis* for *Ophiopholis aculeata*, I think I have gone too far, because the name *bellis* of Linck is used as part of a diagnosis and not as a name. I was, however, encouraged in the selection by the usage of Johnson and of Forbes.

As to the second point, Dr. Lütken expresses great astonishment, "after all that has been written," that anybody should change the *authority* with each change in the *combination* of a name. For instance, we have, in 1854, *Ophiura nodosa* Ltk. I afterwards attempted to show that *Ophiura* was preoccupied, and made a name, *Ophioglypha*, to take its place; and the question now is, Shall it be written *Ophioglypha nodosa* Ltk. or *Ophioglypha nodosa* Lym.? Dr. Lütken has no cause for astonishment. There are two parties to this question. That to which he belongs insists on considering *credit* or *honor* the real reason for using names of authors; and always speaks of the "injustice" done when an author's name is lost sight of. The party whose views I hold maintains that nomenclature is *a system of exact registration*, and that, with the present enormous mass and confusion of titles, no other guide is possible; and further, that the credit of a zoölogist does not rest on his monogram, but on something better. Will the reputation of John E. Gray be greater because his name thus appears often; or will that of Lacaze-Duthiers be less because his appears seldom? After what I have said in the Bulletin (Vol. I. p. 336, note), I can add nothing more to the point than a quotation from Alexander Agassiz (American Naturalist, Vol. V. p. 354):—

"The history of the present confused condition of nomenclature is an interesting one; it is the attempt to show by the binomial system, not only the correct name of any animal, but, at the same time, give a short historical sketch of the changes the name has undergone. The name of an animal or plant is that binomial combination which it has first received, let us say *A b* from Linnæus; [*A* (generic) *b* (specific)]. Subsequent changes, such as the transfer of this to a different genus, *B*, by Cuvier, are simple matters of registration, a part of the *history of the science*, showing what Cuvier thought of the affinities of the species named *A b* by Linnæus. When, then, we speak of this species as *B b* Cuvier, we are recording his views as an investigator, and this does not lessen whatever credit there may be in the original description of *A b* by Linnæus. If afterwards Blainville comes and says that Cuvier should have referred *A b* to the genus *C* of Latreille, and quotes this species hereafter as *C b* Blainville, he is only recording his opinion, and so on through indefinite time. *Changes which the progress of science render necessary in the position of A b of Linnæus are or should be quoted under the*

authority of the author who proposes them as expressing the actual condition of our knowledge of the affinities of the species A b of Linnæus."

At any rate, let the decision be what it may, Dr. Lütken need have no fear that his own reputation rests on any such unstable basis. To sum up, *Astrophyton costosum* Seba, and *Ophioglypha nodosa* Lyman, mean just what they should mean, and nothing more; to wit, that in the writings of these two persons will be found these names definitely, used for the *first time*. They do not distinguish these persons as good or as poor zoölogists, nor do they show that such names are the correct ones; but they are simply the "trade-marks" of workmen.

As to the "Synopsis" of *Ophiuridæ* presented by Dr. Lütken (l. c. p. 87), I have no objection to it, provided it be understood as a movement towards a true classification, or as a really convenient tabulation of genera. But inasmuch as it rests on the structure of the mouth parts it cannot be expected to be an exposition of nature, any more than can a classification of fishes based on their scales; of mammalia, on their nervous centres; or of molluska, on the character of their shells. Any one who will examine the single original genus *Amphiura* will be convinced how impossible it is to arrange it only on the *number* of the mouth-papillæ. In fact, the species of *Ophiuridæ* are now so numerous, that some one man must examine them all with his own eyes, before we can hope for a good arrangement. And especially do the genera *Ophiocoma* and *Ophiothrix* need severely to be weeded.

DESCRIPTION OF THE PLATES.

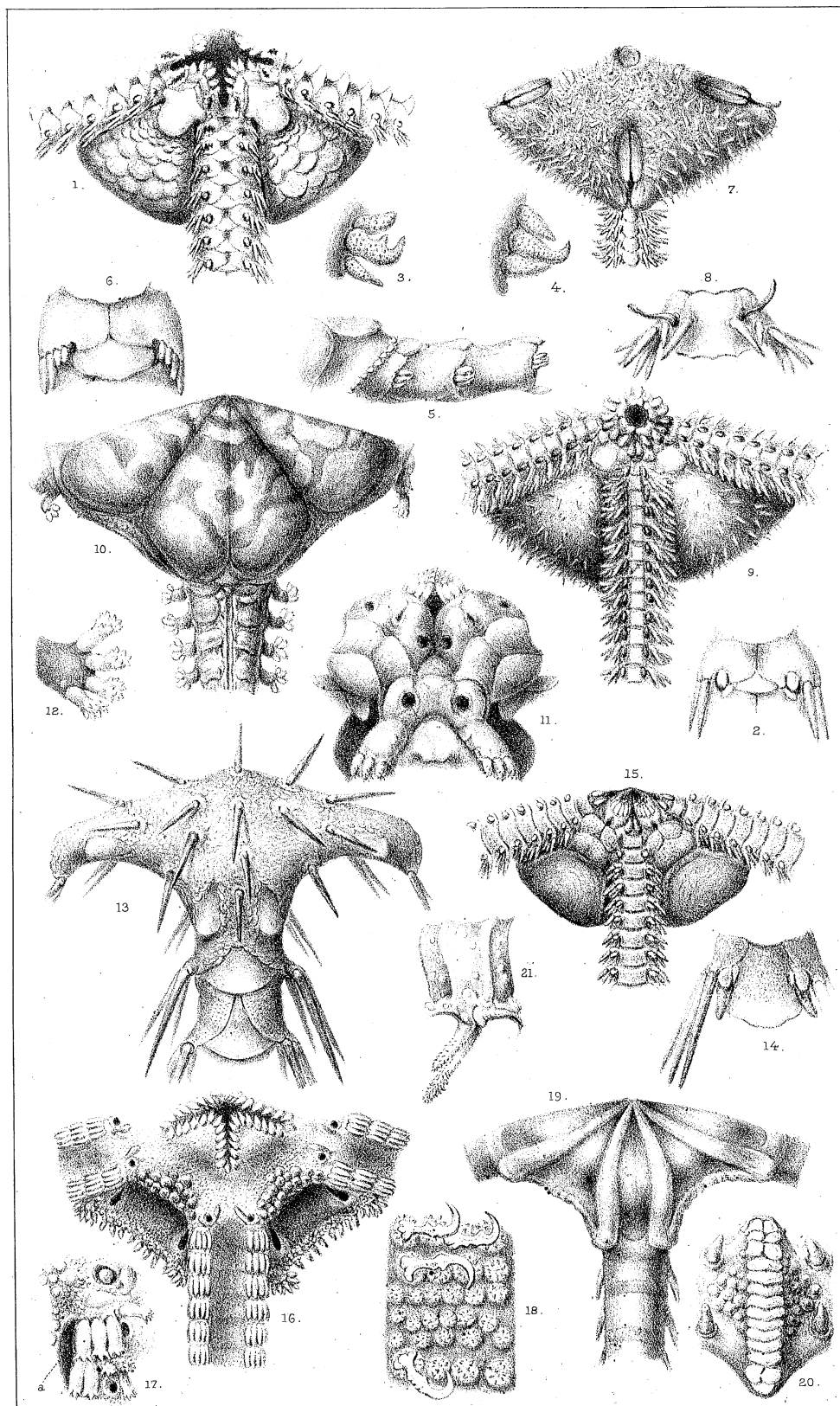
These are all alcoholic specimens; but, in drawing them, the spirit was allowed to evaporate, so that the details could be properly seen.

P L A T E I.

- Fig. 1. *Ophioglypha sinensis*.
 “ 2. “ “ under side of sixth arm-joint, to show the position of the tentacle-scales.
 Figs. 3, 4. *Ophioglypha falcifera*; arm-spines of the basal joints.
 Fig. 5. “ “ base of the arm in profile, with edge of disk and comb of papillæ.
 “ 6. *Ophioglypha acervata*; under side of an arm-joint. (The lobe on the outer side is not made distinct enough.)
 “ 7. *Ophiocnida olivacea*.
 “ 8. “ “ under side of an arm-joint showing the spine-like tentacle-scale.
 “ 9. *Ophiocnida Putnami*. The little organs at the outer corners of the mouth-slits are the mouth-tentacles.
 “ 10. *Ophiothela tigris*.
 “ 11. “ “ enlarged view of the parts near the mouth, and of the first and second under arm-plates, and the first set of arm-spines.
 “ 12. *Ophiothela tigris*. One of the pad-like side arm-plates bearing its arm-spines.
 “ 13. *Ophiomastix janualis*.
 “ 14. “ “ under side of an arm-joint, showing the small and great tentacle-scales.
 “ 15. *Ophiomaza cacaotica*.
 “ 16. *Astrogomphus vallatus*.
 “ 17. “ “ first sets of arm-spines magnified; *a*, head of the genital-slit.
 “ 18. “ “ a piece near the tip of the arm, highly magnified, showing the granulations on the arm-joints, and the ridges of larger granules, between the joints, on which stand the hooks.
 “ 19. *Ophiocreas lumbricus*.
 “ 20. “ “ an angle of the mouth seen from within, showing the column of teeth, and on each side a bunch of granules or small papillæ, beyond which appear the two pairs of mouth-tentacles.
 “ 21. *Ophiocreas lumbricus*; an arm-joint showing the thorny arm-spines.

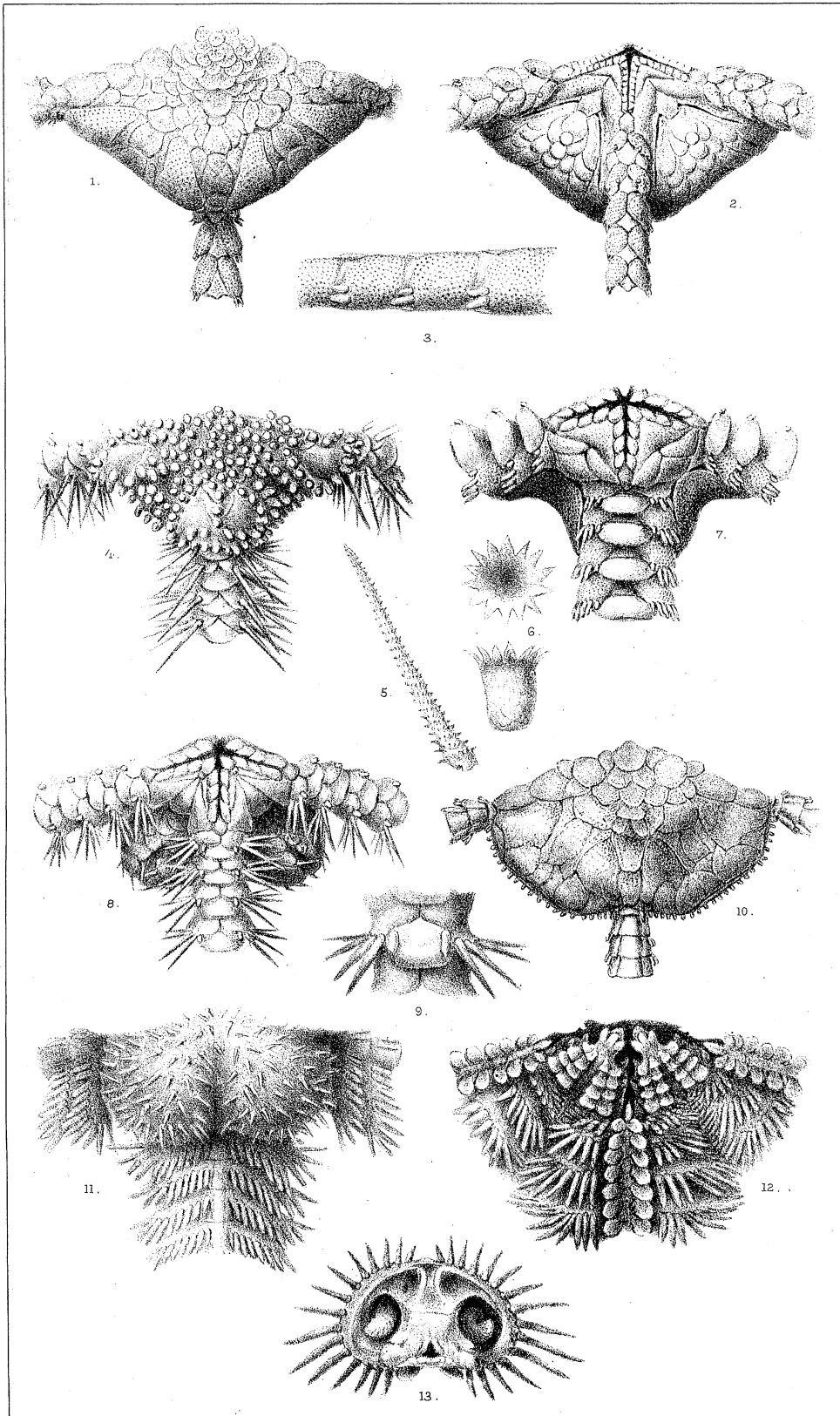
P L A T E II.

- Figs. 1, 2. *Ophiomusium eburneum*, from above and below.
 Fig. 3. “ “ arm from the side.
 “ 4. *Ophiomitra valida*.
 “ 5. “ “ an arm-spine.
 “ 6. “ “ thorny stumps from the disk.
 “ 7. *Ophiochondrus convolutus*.
 “ 8. *Ophiothamnus vicarius*.
 “ 9. “ “ an arm-joint from below.
 “ 10. *Ophiocten depressum*.
 Figs. 11, 12. *Ophiomyces frutectosus*, from above and below.
 Fig. 13. “ “ arm-joint in section showing the retracted tentacles and the arrangement of the arm-spines.



F. Roettler on stone from nat.

Print by H.W. Longfellow.



P. Roetter on stones from nat.

Print by H.W. Longfellow.

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VOL. II. No. 9.

ON SOME INSECT DEFORMITIES.

By DR. HERMANN A. HAGEN.

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NOTE.

THE quarto publications of the Museum will hereafter be issued under the title of "Memoirs of the Museum of Comparative Zoölogy." In order not to commence a second series, the numbers of the Illustrated Catalogue already issued have been combined to form the first volumes of these Memoirs. Title-pages and tables of contents of the three volumes already completed are sent with the present number.

ALEXANDER AGASSIZ.

ON SOME INSECT DEFORMITIES.

IN arranging the Lepidoptera of the collection, I found, among the insects brought home from Brazil by Professor L. Agassiz, a specimen of *Morpho Eurylochus* with the head of the caterpillar. The excellent condition of the large specimen induced me to compare all published observations of a similar deformity. These are few, and scattered in transactions not easily accessible. Therefore I concluded to reprint the full text for the two oldest known, and to give copies of the figures, together with those of *M. Eurylochus*. In the hope of having information about other similar cases, I published a provisional paper in the Stettin Ent. Zeit. (1872), p. 388, and I am indebted to Professor Zeller of Stettin, Professor Westwood of Oxford, Mr. McLachlan of London, and Dr. J. L. Leconte of Philadelphia, for additional information.

The rare and less known paper of Mr. C. Majoli, on a precocious development of *Bombyx Mori*, and the notice of two deformities of Coleoptera, seemed to me not out of place in this paper.

PERFECT INSECTS WITH THE LARVAL HEAD.

Phalæna heteroclita.

The well-known Danish naturalist, Professor O. F. Mueller, has described (1764) in his *Fauna Fridrichsdalina*, p. 47, No. 413, a new species of *Noctua*, found by himself at Fridrichsdal, a locality a few miles distant from Copenhagen.

Phal. N. heteroclita subcristata, capite erucæ, antennis nullis: alis albis, lineis transversim undatis punctatisque marginalibus nigris. In *Epilobio*.

This description is verbatim, repeated by himself in his *Prodromus Faunæ Danicæ* (1776), p. 124, No. 1428.

In the *Mém. de Mathém. et de Phys. présentés à l'Acad. R. des Sciences à Paris* (1774), Vol. VI, pp. 508 – 511, pl. 1, Professor O. F. Mueller has given a detailed account of this most remarkable speci-

men, believing it to be a new and very curious species of Lepidopteron, with all the characters of the order, except that the head is exactly that of a caterpillar. In the same volume of the *Mémoires*, the editor (Préface, p. 8) believes it more prudent not to admit Mueller's insect as a new species, because a fact contrary to all hitherto known must be proved by a great number of observations before it can be adopted by the scientific world. Professor Beckmann, the reputed polyhistor from Goettingen, in his *Physik. Oekon. Bibliothek*, Vol. VI, p. 338, believes that Mueller's insect is only a deformity. A review of Mueller's paper in the *Comment. Lipsiens.* (Vol. XXI, p. 466) I have not seen.

The French paper is translated by the Rev. J. A. E. Goeze, in the 16th part of the *Naturforscher* (1781), pp. 203 – 212, pl. 1. The plate is of course the same as Mueller's plate, but somewhat inferior in execution. The translation, in some places at least, does not entirely agree with the original, as Goeze introduces some suppositions to explain more fully Mueller's words, which are not everywhere free from ambiguity. But it is to be remembered that Goeze had spoken of the whole with Mueller, at a visit paid to him by the latter in 1776. At that time the type was still present in the collection of the author, which was afterwards destroyed at the bombardment of Copenhagen. In my *Bibliotheca Entom.* (Vol. I, p. 556) I stated that the insect was *Bombyx dispar*, which is apparently an error. Westwood (Introduct., Vol. II, p. 356) calls it one of the Noctuidæ; and Lacordaire (Introduct., Vol. II, p. 442), une Noctuelle. The insect is not mentioned in the general works of Borkhausen and Ochsenheimer, but Werneburg (*Beitr. zur Schmetterl. kunde*, Vol. I, p. 376), quotes it as *Bombyx monacha*, and there is no doubt that this determination is a correct one.

Mueller found the insect alive, quietly sitting on a stem of *Epilobium montanum*, on July 28, 1762, pinned it, and only became aware at home of the remarkable fact that the head of the caterpillar was still existing on the moth. Both Mueller and Goeze give as the date June 28, apparently erroneously, as in the paper it is twice stated that the insect lived ten days on the pin, until the 6th of August, when it died. From June 28 to July 6 there are only nine days.

The description by Mueller is as follows:

Nearly the size of *Phal. vinula*; upper wings white, with several transverse zigzag lines, the border spotted with black; hind-wings smaller, grayish, the border with alternate black and white spots; all the wings blackish underneath, the border spotted with black; abdomen black, somewhat hairy, with five yellow rings, which are broad above, narrower beneath, and twice interrupted; the tip of the abdomen pointed, yellow, with a yellow ovipositor; the prothorax densely covered with white hairs, sprinkled with black; the thorax with four legs, black and gray-colored; the tibia with two spurs on the inside.

“La tête ” (I give purposely Mueller’s words), “cette étrange partie, est grisâtre et arrondie, plate au devant; elle est composée, comme le sont ordinairement les têtes de chenilles, de deux lobes latéraux, grisâtres et pointillés en noir, lesquels se joignant par-dessus, laissent au milieu une figure triangulaire et brune. C’est une membrane mince, qui à l’aide d’une loupe, laissait entrevoir une liqueur transparente, agitée d’un mouvement continu. Il y a au bas du triangle deux petits corps ovales, qui avancent sur deux organes noirs, lesquels se répondent exactement et se choquent, au milieu de l’embouchure, comme deux marteaux. On voit à côté deux organes émoussés de couleur jaune, qui dans les chenilles sont communément garnis d’un poil fin, ce qui manque ici; plus bas, il s’avance des côtés deux crochets coniques et jaunâtres qui se touchent au milieu de la bouche; à l’entour on voit quelques taches incarnates et grandes; plus à côté quelques points brillants et par-ci par-là quelques petits brians de poils.”

The moth lived ten days, and deposited a number of green eggs, most of them on the first and second days, some on the latter days up to the 6th of August, when it died. The eggs were not developed.

Mueller repeats a second time (p. 511): “On voit clairement le mouvement peristaltique de la liqueur sous la membrane triangulaire, aussi bien que le mouvement des organes de la bouche; il ne s’en trouve pas la moindre trace des antennes et trompe.”

It would not be justifiable to consider this statement pure and simple an error, inasmuch as Mueller was undoubtedly one of the most prominent naturalists, and must have known very well the importance of the described facts. If the statement of Mueller is accepted as correct, the specimen is an exception, and differs considerably from all others as yet recorded. It must have been an imago, with the head of the caterpillar preserved; not only with the skin covering the head of the imago preserved, but with a real head of the caterpillar, in which the circulation of the blood is still taking place, and the maxillary organs are still movable. Such a condition of the parts is contrary to all our present knowledge of the anatomy and the development of insects. It is remarkable that the forelegs have not been developed, as the superior part of the prothorax is similar to that of the imago. But Mueller records and figures only the four posterior legs.

The opinion of Mueller, that his moth represents a new and somewhat intermediate genus and species, is of course an erroneous one. The supposition by Kirby and Spence, *Introd.*, Vol. III, p. 121 (transl. Oken), that the head was damaged perhaps in the caterpillar state by some parasite, and the caterpillar therefore was unable to cast off its skin, needs no refutation. I cannot give any probable explanation of the fact; perhaps it was a monstrosity, never observed but in this isolated specimen.

Mueller's observation was accepted by the prominent naturalists of the time, — for instance, by Bonnet. Later J. F. Meckel (Handb. der pathol. Anatom., Vol. I, p. 55) explained the fact as an arrested development of the insect. Dr. Stannius (Mueller's Archiv., 1835, p. 296) accepts this explanation. J. van der Hoeven (Tijdschr. voor natuurl. Gesch., Vol. VII, p. 274) believes the case to be just like that of Wesmael and rejects the opinion of Mueller concerning the head; but I think he has not given strict attention to Mueller's statements.

Nymphalis Populi.

Professor Wesmael gives in Bull. Acad. Bruxelles, 1838, Tom. IV, p. 359, reproduced partly in Ann. Scienc. Nat., Ser. 2, Vol. VIII, p. 191, a description and colored figure of this insect. If I am not mistaken, I saw, in 1870, the type in the Museum in Brussels. He caught the specimen in July, near this city. The insect had the thorax, abdomen, legs, and wings perfectly well developed and colored, but with the head of the caterpillar. The insect turned the curious head to the right and left, and tried, by a quick motion of the forelegs, to push it off. Mr. Wesmael, in dissecting the left side of the head, discovered underneath the external skin a second one much thinner than the first, and beneath the second one the well-developed eye of the butterfly. The parts around the eye were covered, as commonly, with scales. Therefore Wesmael considers the second skin as that of the chrysalis, and believes the deformity originated by the inability of the caterpillar to cast off the head.

Underneath the head of the caterpillar, and just above the skin of the chrysalis, was the left antenna, coiled up, but without an apical knob. The antenna was covered by a very fine membrane, which was to a great extent diaphanous, and transversely striated with brown. The left palpus was free, normally developed, and turned horizontally backwards. The right palpus seemed broken off; the place of its insertion was clearly visible. Mr. Wesmael says nothing about the prothorax; as the forelegs were free and movable, it must have been without any covering.

This butterfly differs essentially from the moth described by Mueller. The head shows only the skin of the caterpillar, which really has gone through the transformation into the head of the chrysalis, and later into the head of the imago, retaining throughout the skin of the former stages, one above the other. The recorded movement of the head was apparently done by the movement of the head of the imago. Wesmael makes the following conclusions: —

1. The insects which are obliged to undergo transformation may have only a partial one, which does not prevent the total transforma-

tion of other parts; even if the untransformed parts are important to the life of the animal. He believes this to be a natural consequence of the segmentation of the body of the arthropods.

2. The accidentally covered parts nevertheless go through all transformations which are necessary for the insect to arrive at the imago state. The second conclusion is of course not to be accepted, if the facts recorded by Mueller are adopted.

Morpho Eurylochus.

Among about a dozen specimens of this butterfly brought home by Professor L. Agassiz from Brazil, one male has retained the head of the caterpillar. The specimens are from Canta Gallo, communicated by Dr. Teuscher. Their perfect condition leads me to suppose they were reared from the chrysalis.

The quoted male is in perfect condition, and, as all others, entirely well developed in size and in colors. The head of the caterpillar is retained and perfectly preserved in shape and in color; the minute yellow hairs which cover the head are in good condition, and the spines are scarcely crumbled. Beneath the head the mentum is broken off near the prothorax. Its lateral sutures are separated, and the mentum hangs down as a kind of trap-door, being united with the head only by a small anterior lobe. This kind of adjustment leads me to suppose that the mentum was broken by the pushing out of the spiral tongue of the imago. The opening is large enough to show that the head of the caterpillar is empty inside. The skin between the head and the prothorax is still preserved in the shape of a contracted ring, which is open only for a small space beneath, where the mentum is separated. The large dorsal plate of the prothorax is present, and covers loosely the thorax of the imago; on the left side the external third is wanting. The palpi are rejected to the thorax, but the right palpus has the two basal thirds covered by the skin of the caterpillar, which is connected with the dorsal part of the prothorax. Behind the palpus and rather near to it can be seen the free foreleg of the right side. Its limbs are well developed, neither as stout nor as hairy as in the other specimens. The left palpus, though not covered, seems to be shorter and less hairy than the right one. The left foreleg is covered by the femur of the middle leg. I am not able to state whether any part of the skin of the chrysalis, either beneath the dorsal plate of the prothorax on the middle and on the right, or on the entirely free left side of the thorax, is present. Perhaps the skin of the chrysalis is broken off just at the ring formed between the head and the prothorax. I am unable to see the skin of the chrysalis inside of the head of the

caterpillar through the small opening of the mentum. As the skin of the chrysalis must have existed, I did not deem it necessary to dissect the specimen, especially as Wesmael's dissection of *Nymphalis Populi* has sufficiently explained the fact.

The head of the caterpillar resembles very much the figure in Merian Surinam. Lepid., pl. 23. The color is leather-yellow, with two brown bands on each side. There are two yellow finger-shaped horns on the top, and three similar ones on each side; they become successively smaller. The last one is very short.

The specimen has doubtless lived long enough to get the colors perfectly developed, and to break down the mentum with the spiral tongue. It differs from Wesmael's butterfly in having retained the dorsal part of the prothorax, though somewhat distant to allow a view of the thorax of the imago. In Wesmael's butterfly the palpi were not covered. I have quoted erroneously, in the Proceed. Bost. Soc. N. H., 1868, Vol. XII, p. 163, the Brazilian specimen as *Morpho Thoneus*, and Mueller's specimen as *Dicranura vinula*.

Vanessa Antiopa.

Professor Zeller has described in the Isis, 1839, p. 259, a specimen with the head of the caterpillar, raised by himself together with about 150 others. The specimen differs from them only by the presence of the head of the caterpillar, which is in a vertical position, just as in the caterpillar. The mouth is closed. Having cut a part of the left side, the Professor could observe a hollow space between the head of the caterpillar and the remaining parts of the insect. Behind the head and not connected with it the two anterior plates of the chrysalis are retained. The butterfly made its transformation in the absence of the Professor, and was pinned at the same time with all the others. It was impossible to find its chrysalis skin.

Vanessa Atalanta.

Mr. Bond exhibited in the Entomological Society in London, February 6, 1871, a specimen bred by a metropolitan collector, which still bore the larval head. The specimen, as I am informed by Mr. McLachlan, was very perfect.

Pieris Rapæ.

Among a number of chrysalids which had not transformed, I found in the fall of 1871, in Cambridge, one of an extraordinary appearance. In casting off the skin of the caterpillar only the thoracic part of the

chrysalis was developed; the head of the caterpillar was still present, but its sutures were separated. The dorsal split of the skin reaches the first segment of the abdomen, and the skin of the abdomen is retracted, but still present.

A similar specimen was observed last fall by Mr. S. H. Scudder.

***Zygæna exulans* var. *Vanadis*.**

Dr. Staudinger, in a paper on the Lepidoptera of Lapland in Stett. Entom. Zeit., 1861, Vol. XXII, p. 359, records a larval-headed male of this species, found, July 11, near Bossekop. The specimen is fully developed, with the head of the caterpillar. The mouth parts were immovable in the living insect; the head was fastened to the prothorax, and moved only by the motion of the prothorax. The latter is fully developed beneath, and with its legs; above there is a horny black vaulted ring, somewhat hairy on the left side. Mr. Staudinger believes it impossible that the head of the imago is enclosed in this larval head.

***Sphinx* spec.**

Mr. Trouvelot assured me that he had caught in Cambridge several years ago, a *Sphinx* with the head of the caterpillar. The specimen is no longer in existence.

Professor Van der Hoeven, in his quoted paper, p. 274, records that he has seen a caterpillar of *Sph. Tiliae* which had not been able to cast off in the last moult the skin covering the spine of the tail. The caterpillar died before the transformation.

***Bombyx* *Mori*.**

Mr. J. J. Bruinsma, in Tijdschrift voor Natuurl. Geschied, 1840, Vol. VII, pp. 257–270, pl. 1, has published detailed observations concerning the same deformity, accompanied by figures.

Having read Wesmael's paper, Mr. Bruinsma concluded to try his own observations in raising silk-worms. In the course of the summer he found some specimens, which did not agree exactly with Wesmael's butterfly, but seemed interesting for publication. But shortly after Mr. S. Van Leuwen, also interested in the same kind of observations, communicated to him, August 9, a chrysalis with the upper part of the larval head still remaining. The chrysalis was fourteen days old, and had been taken out of a cocoon, in which the skin of the caterpillar was found. The skin showed nothing unusual, except that the head, which commonly remains united with the skin, was broken off.

The chrysalis was of medium size, rather lively, and perfectly developed. To the upper part was fastened with a collar the caterpillar's head, split in two lateral parts, which are united together in the common caterpillar head. The mouth parts of the caterpillar were still remaining, but between them another prolongation could be seen. The nympha is figured in different views, Figs. 1 – 4.

The chrysalis transformed, August 26, into a moth with the caterpillar head. The chrysalis had the skin split as usual on the dorsal part. So the moth left the chrysalis in the usual way, and was perfectly developed (Fig. 5), except that the right foreleg was smaller than the left one, but otherwise well formed. Therefore the moth stood somewhat obliquely. It was a male, rather lively in his movements, and used both forelegs to push off the caterpillar head, by which it was seemingly annoyed. The head of the caterpillar covered exactly the place where the head of the moth should be, so that nothing was to be seen of it, nor of its antennæ or eyes. On the prothoracic border the same elongated part was to be seen as in the chrysalis, without any hairs, consisting only of a brownish membrane. The side parts of the head were fastened to it just as in the chrysalis. The right part was taken off, and beneath it the right antenna was discovered, well formed, but coiled up. In taking off more of the skin, a well-formed eye of the perfect insect appeared.

Mr. Bruinsma explains the fact by the difference of the last moult from the four preceding ones. He states that in the last moult the skin splits near the tail, and the chrysalis comes out backwards, by which process the head is sometimes not able to follow. I confess that this statement is entirely new to me, and disagrees with Malpighi's description.

Mr. Bruinsma concludes his paper with some observations made on caterpillars which, after having spun the cocoon, were taken out and obliged to spin a second cocoon. This was only imperfect, so that a full observation of the caterpillar was possible. Mr. Bruinsma observed that one of them formed a chrysalis with the head of the caterpillar. But the chrysalis died very soon. Two of the caterpillars are figured.

Professor J. Van der Hoeven has published a paper in the same journal, following that by Mr. Bruinsma, pp. 271 – 275, about perfect Lepidoptera with the larval head remaining. He draws attention to an old observation by J. Jonston, published in his *Hist. Natur. de Insectis*, Amstelod, 1657, p. 123 (Edit. Heilbr., 1768, p. 176). The account by J. Jonston is very detailed, and concerns a male and a female of *B. Mori*. The male was in the chrysalis state, the anterior part covered with the parts of the caterpillar. The imago was not able to cast off the skin, died, and was dissected. The head of the imago was found to be fully developed.

The female showed perfectly well the head of the caterpillar, and beneath it the skin of the chrysalis, containing the head of the imago.

“Itaque ibi senectæ caput [head of the caterpillar], nymphæ vertex et necydali [imagine] conjuncta conspiciebantur; quæ conjunctio retinebat senectam [skin of the caterpillar] in ventre, ne potuerit potius avelli et destrungi. Ideo et cohærebat, cum alvi acumine, non aliter ac si quis sacco fuit inclusus; et circa caput astrictus; facto vero in tergo foramine dorsum extraxisset quidem, sed adhuc hæreret capite et podice, ita jacens incurvus et exanimis. Sic habebat senecta (the caterpillar). Ex hac prominebat et aurelia [chrysalis], quod attinet partem superiorem. Ex aurelia vicissim necydalus [imago] fere totus eluctatus erat, fracto putamine in dorso, solitaque regione; sed capita cohærebant indivulsa, sicut et alvi extrema. In ventro exorto magna copia ovorum conspiciebatur colore flavo.”

The statement of the skin of the caterpillar split on the dorsum disagrees with the statement by Mr. Bruinsma.

Professor Van der Hoeven (ibid., p. 274) communicates, in a letter to Mr. A. Brants, November 26, 1839, that Mr. Einodhven, in his silk-worm nursery at Brummen, Holland, had observed several times imagines with the head of the caterpillar. Mr. Brants was able to take out of one of them the perfectly developed head of the imago. The antennæ were coiled up, covering the eyes of the insect.

Mr. Bond exhibited in the Entomological Society in London, February 20, 1871, a specimen of *B. Mori* retaining the larval head. The specimen was somewhat crippled and very small, as I am informed by Mr. McLachlan.

Gastropacha quercifolia.

A specimen with the larval head is recorded by Professor Westwood in Entomol. Month. Magaz., No. 82, p. 239.

Zerene adusta.

I am indebted to Professor Zeller for the details of this. Among a number of caterpillars of this species, one transformed in a chrysalis, with the head of the caterpillar. The chrysalis died, perhaps because it was kept too dry. Otherwise probably a moth would have been reared, as the chrysalis was perfectly developed. The head of the caterpillar was in perfect condition, but placed so far beneath that the chrysalis had a hunchbacked appearance. The face and the ventral side met in an acute angle; a collum was wanting, but the head was round, separated more deeply below. As all parts of the head of the chrysalis are covered by the head of the caterpillar, there are no an-

tennae covers visible. The furrow in which the antennæ should have been placed begins very shallow on the prothorax, near the head, and runs between the front margin of the anterior wings and the hind legs, somewhat longer on the right side. This furrow is largest along the tibia. The covers of the palpi and the tongue are wanting.

Botys fuscalis.

Mr. Stainton exhibited in the Entomological Society in London, a specimen with the head covered by a part of the puparium, caught on the Isle of Man. It was flying briskly when captured, and was otherwise perfectly developed. The antennæ and the haustellum were free, and the case of the latter projected downwards like the rostrum of a *Panorpa*. I am indebted to Mr. M'Lachlan for the communication of this case.

Of insects not belonging to Lepidoptera, only four with a similar deformity are known.

Cybister limbatus.

Mr. Smith (Proceed. Entom. Soc., London, Ser. 2, Vol. IV, p. 34) exhibited a specimen with the larval head, caught swimming near Hong-kong in China.

Dytiscus marginalis.

Professor Westwood (the Entom. Month. Mag., No. 82, p. 239) stated that he had seen a specimen with a larval head.

Hydaticus bimarginatus.

I am indebted to Dr. John L. Leconte for the information that a specimen of this beetle, with the larval head, is in the collection of Dr. Helmuth in Chicago.

Syrphus spec.

Professor Westwood (ibid.) states that he had observed one specimen with a larval head.

I am indebted to the same professor for the communication that he is about to publish a dozen cases of perfect insects with the larval head, all of which he has figured.

The specimens mentioned above are : —

- Lepidoptera. — 1. *Vanessa Atalanta*.
2. *Vanessa Antiopa*.
3. *Nymphalis Populi*.

4. *Pieris Rapæ*.
5. *Morpho Eurylochus*.
6. *Zygæna exulans*.
7. *Sphinx spec.*
8. *Bombyx Mori* (several times).
9. *Liparis Monacha*.
10. *Gastropacha quercifolia*.
11. *Zerene adusta*.
12. *Botys fuscalis*.
- Coleoptera. — 13. *Dytiscus marginalis*.
14. *Hydaticus bimarginatus*.
15. *Cybister limbatus*.
- Diptera. — 16. *Syrphus spec.*

Only the fact of the presence of the larval head is known for the Nos. 7, 10, 13–16. More or less sufficient details are known for Nos. 1, 3, 8, 12, but the publication by Professor Westwood will give doubtless a full information about them. The Nos. 4, 11, were only in the chrysalis state, and do not strictly belong here. But just those cases are interesting, as all the others must have passed the chrysalis state in the same manner.

The Nos. 1, 2, 8, and probably 5, were bred by home raising; Nos. 3, 6, 7, 9, 12, 15, were caught living.

The interesting fact that the larval head is sometimes retained in the perfect insect is proved by the quoted observations. Probably all cases except *Noctua heteroclita* belong to the same kind of deformity. The head of the imago is contained in the head of the larva, which the insect was not able to cast off in the transformation. It must be admitted that circumstantial details are known only for *V. Populi*, *V. Antiopa*, *M. Eurylochus*, *Z. exulans*. The prothorax of the two last-mentioned species, and even one foreleg in *M. Eurylochus*, is still covered by the larval skin. The antennæ are free in *B. fuscalis*; the palpi are rejected in *V. Antiopa*, *V. Populi*, *M. Eurylochus*; in *Z. exulans* they are free. All specimens were fully developed in size, shape, and colors, except *B. Mori*.

Perhaps such deformities are not so rare as the small number of known cases would lead us to believe. Such deformed specimens are more easily caught and destroyed by their natural enemies, or they die sooner for lack of food. Nevertheless, the very large number of Lepidoptera bred and raised during the past hundred years allows us to conclude that at least in home raising such deformities occur very rarely. Mr. Trouvelot observed many times *T. Polyphemus* caterpillars casting off the larval head with more or less difficulty, and sometimes not at all. The last case proved to be fatal. As insects of course are developed more easily in liberty than in captivity, the rare occurrence of perfect

insects retaining the larval head may depend on the larger mortality of their caterpillars.

There is very little known concerning the physiological and mechanical processes shortly before or during the act of transformation of arthropods. Nearly all entomological works state that the larvæ moult or change their skin several times, that the larvæ become restless some days before the change, stop eating, and desert their food; later, the skin splits, and the insect perfects its transformation.

I believe there exist few men who have not seen and observed once in their life this wonderful spectacle. The proceedings are so common, and always so easily performed, that observers are not induced to think about the manner in which transformation is effected, nor about the mechanical acts providing the possibility of such a change. Concerning the mechanical acts, so far as I know, nothing is published. An animal, or even a man, covered with an artificial skin well fitted to the whole body, obliged to go out of the skin through an aperture made of similar size and relation as that in insects, would scarcely be able to do it without a violent use of the limbs. Insects use their limbs very little or not at all in the beginning of transformation, but nature has provided some help in the necessary coincidence of certain physiological proceedings just at the time of transformation.

I have observed many times and in different insects, before transformation, a very accelerated and excited action of the dorsal vessel. The same fact is recorded by other observers, for instance by Mr. Weismann and Mr. W. Blasius. After observations of Mr. W. Blasius (*Zeitschr. f. wiss. Zoöl.*, Vol. XVI, pp. 135 – 177), during the transformation of the caterpillar into the chrysalis, the action of the dorsal vessel increases successively in the first three hours, and reaches its maximum in the last half of the fourth; after that time the action begins to decrease, and becomes in the eighth hour equal to the action in the third hour. The consequence of an accelerated action of the dorsal vessel is an increased circulation of the blood, going from the tail to the head. This sudden rush of an unusual quantity of blood to the head and the thorax, without any corresponding arrangement for convenient emanation, swells those parts, pushing them forward at the same time. Finally the skin bursts, and one of the most important acts of the moult is performed.

I suppose that the frontal bladder, which is observed in transforming Diptera and Odonata, is the consequence of the rush of blood; nevertheless, an observation recorded by Weismann seems to disagree with such a supposition. It should not be overlooked that some other purely mechanical proceedings seem to accompany and help the propulsion of the insect by the rush of the blood in a very easy manner. I have described long ago a related fact in regard to the moult of *Ephemera*,

Stettin. Ent. Zeit. (1849), p. 365. The segments of the abdomen possess on each side an apical spine. By a continuous movement of the abdomen to the right and left, those spines press successively against the loosened skin, forcing forward the transforming insect. Probably similar arrangements will be found in other insects.

The causes why such a rush of blood originates just at the time of the moult, I find nowhere recorded. I think it not sufficient to consider it as a simple consequence of an action of the nervous system, especially as I believe myself able to give a more plausible explanation.

The crust of insects consists of the external chitinated epidermis, and the internal soft hypodermis. Above the latter, which becomes somewhat separated from the epidermis, the new skin is to be formed, at first without impediment to the functions of the insect. As long as the more or less isolated parts of the new skin allow a free circulation of the blood around and between them to feed the old epidermis, the action of the dorsal vessel follows its regular way. By and by the isolated parts of the new skin become larger, and partly united, until finally the whole new skin is already formed and chitinated. The circulation is at first only disturbed; later, it is impossible for it to flow in the old way and to the old skin, and the blood, obliged to turn in another direction, rushes naturally in the easiest one, to the dorsal vessel. This is the moment of the beginning of the rush of the blood to the head; of course the nervous system, irritated by the rush, will help to accelerate more the action of the dorsal vessel.

It is obvious that the new skin, at least in some parts of the body, must exercise a more or less strong pressure against the old skin. I am of the opinion of Dr. Gerstaecker, that the moult is not alone a consequence of such pressure; but in some parts, for instance in the head, the pressure is obviously prevalent, and must originate a partial resorption of the old epidermis, as that of the thicker sutures. At least, thus the splitting of the sutures in many insects could be explained; I say purposely in many insects, because a large number transform in a different way. In some Lepidoptera the skin of the head does not split. Mr. Trouvelot (Americ. Natur., I, p. 37) records for *Telea Polyphemus* that the skin splits transversely under the neck just at the end of the head, and perhaps in some way laterally, and probably behind or through the whole prothorax. "When about one half of the body appears the shell of the old head remains like a cap enclosing the jaws; then the worm, as if reminded of this loose skull-cap, removes it by rubbing it on a leaf."

I was able to verify Mr. Trouvelot's observation on a cast-off skin of *T. Polyphemus*. However, in the nearly related species *Att. Cecropia*, *Promethea*, *Yama-mai*, I found that the sutures of the head always split in the regular manner. According to Kirby and Spence, the manner of

splitting is not the same for all Lepidoptera. Most of them split at first the dorsum of the second and third segment of the caterpillar. *Pieris crataegi* is stated by Bonnet to split its skin only in the head; and Reaumur records for *Zygæna filipendulæ* that the caterpillar bites off pieces of the old skin and puts them aside. Besides those old observations there exists a large number of recent ones. Generally it is true that Coleoptera, Orthoptera, Pseudoneuroptera, Diptera, Hemiptera, at least the Homoptera, and the larger part of Lepidoptera, split first the frontal sutures of the head.

It is of interest that the well-known *Limulus Polyphemus* splits in the moult the frontal sutures similar to the insects, and goes out forward of the old skin. I find nothing published about the splitting of the skin of the Crustacea. But the Decapods split along the border of the cephalophorax, and are obliged in moulting to take out the parts backwards. As the systematic position of *Limulus* is still a matter of dispute, I think this fact is of some value.

The restlessness of the insects before the moult, and the fact that they do not need food, are easily understood. It is known that the tracheæ participate largely in the moult. At certain times the inner skin must begin to separate, and it is obvious that through it the respiration will be impeded. Perhaps this difficulty has something to do with the acceleration of the blood. Besides the tracheæ a large part of the digestive canal changes its skin; the anterior part to the ventriculus, and the posterior to the colon. Here also, at a certain time, the inner skin begins to separate, and the natural consequence will be the impossibility of taking any food, or even of ejecting the superfluum contained in the intestines.

All insects, as I stated before, go forwards out of the old skin in transformation. But I find one case of the contrary quoted by Professor Westwood (Brit. Cyclop. Article Insect, p. 844). He says that *Coccus* comes out backward, the wings rejected above the head.

A very remarkable fact is that the females of the Ephemero genus *Palingenia* do not change the skin of the subimago. Swammerdam says the females for the most part do not change the skin; but a very large number of them examined by myself possessed the subimago skin, and I never saw one without it. They undergo copulation and lay eggs without having arrived at the state of a perfect insect.

The instances where insects in the last moult are not able to throw away the skin and carry it with them are in *Ephemera* not very rare, as the long setæ are sometimes fastened in the old skin. But I caught a *Libellula* flying with its nymph skin fastened to the end of the abdomen. The specimen, *Diplax scotica*, is still in my collection. I am indebted to Mr. A. Agassiz for a knowledge of the fact that larvæ of *Radiates* are sometimes found with parts of the foregoing state still attached to the skin.

ON THE PRECOCIOUS DEVELOPMENT OF THE CATERPILLAR DIRECTLY INTO THE IMAGO STATE.

Bombyx Mori.

Mr. Cesare Majoli, in *Giornale di Fisica, Chemica, Storia Naturale del Regno Italico* di L. Brugnatelli, Pavia, 1813, Bim. V, p. 399, describes a curious instance of a precocious development of the well-known silkworm. The book seems to be wanting in all libraries of the United States, and is not even common in Europe. I am obliged to Professor Pelzel in Vienna, Austria, for a written copy of the notice, which I find recorded only in J. F. Meckel's *Archiv f. Physiol.*, 1816, Vol. II, p. 542, and in Lacordaire's *Introd.*, Vol. II, p. 443, and by Stannius in *Mueller's Archiv*, 1835, p. 297. As both differ from each other in some important statements and from the text, I prefer to reprint the original.

Straordinario fenomeno di anticipata trasformazione in farfalla del verme da seta.

Il Sign. A. Farini di Forlì ha comunicato al Sign. Barzoni un'osservazione interessante descritta dal Sign. Lettore Cesare Majoli in un opuscolo M. S. sulla vita, costumi ed educazione del filugello. Sovente aveva sentito raccontare da chi educava i bachi da seta, che pure qualche volta accadeva svolgersi essi in farfalla prima che incominciassero a filare il bozzolo, cioè dopo la quarta muta. Le reputava favole femminili, giacchè nissuno aveva parlato di un tale fenomeno. Ma si è convinto del fatto nel 1792, allorchè chiamato a rendere ragione di esso trovò che due cannicci e stuoje di bruchi erano isfarfallati nella notte antecedente senza formare il bozzolo deludendo così la speranza del coltivatore. In qualcuno degli anni antecedenti accadde pure un somigliante fenomeno, e nel 1811 il Sign. Dott. Siboni gli mandò due di questi aborti volanti generati in una casa di proprietà della Signora Rosatti che lo stesso Sign. Farini ha osservato. Questa farfalla differisce dalla falena bombice per li seguenti caratteri. Ha il capo piccolo, due occhj neri reticolati, il torace quale se fosse il terzo anello dopo il capo del bruco; ha il corpo del bruco istesso all'epoca della quarta muta, pari numero di anelli a quello del bruco; le ali superiori alquanto lunghe e ristrette, le inferiori più corte e strette; ha le antenne alquanto cenerognole in confronto di quelle della falena vera bombice. Il Sign. Majoli espone una conghiettura sopra la cagione del fenomeno mentovato e inclina ad attribuirlo al calore eccessivo del luogo in cui esistevano que' bachi da seta, per cui nel momento in cui filugello sta

per compiere la sua metamorfosi dello stato di bruco, ne altera siffattamente il sistema primitivo, ne promuove una traspirazione straordinaria de' fluidi esistenti nel bruco, e soprattutto di quello che è necessario a formare il bozzolo, e ne accelera cosè la sua metamorfosi d' isfarfallare. Sarebbe stato a desiderare che per confermare in qualche modo l' accennata opinione si fosse tentato artatamente di attenere lo stesso effetto col sottoporre diversi bruchi ad una temperatura calda, allorchè erano vicini alla quarta muta. Interessante sarebbe il sapere se le farfalle che abortirono avevano gli organi della generazione ben formati e capaci come la falena bombice di accoppiamento e di mettere le uova atte a sviluppare a suo tempo il baco.

[TRANSLATION.]

An extraordinary case of a precocious transformation of the caterpillar of Bombyx Mori into the moth.

Mr. A. Farini, in Forlì, has communicated to Mr. Barzoni an interesting observation, published by Mr. Cesare Majoli, about the life, the manners, and the education of the silk-moth. He was told by men occupied with the breeding of silk-worms that it sometimes happens that caterpillars before spinning a cocoon, therefore after the fourth moult, were transformed into moths. He believed it to be only talk, the more so as nobody had published anything about such a case. But he convinced himself of the fact in 1792. Invited purposely to convince himself by his own observation, he saw two boards filled with caterpillars transformed in the preceding night into moths without having spun cocoons, to the regret and deception of the owner. Recently the same fact was observed, and in 1811 he received by Dr. Siboni two such winged deformities, bred by Mrs. Rosatti, and examined by Mr. Farini. These differ from the regularly developed silk-moth in the following characters: The head is small, with two black compound eyes; the thorax similar to the third segment behind the head of the caterpillar, and the abdomen similar to that of a caterpillar at the time of the fourth moult, with just as many segments as the abdomen of the caterpillar; the fore-wings somewhat elongated and narrowed; the hind-wings shorter and narrower; the antennæ grayish, compared with those of the regular silk-moth. Mr. Majoli gives an hypothesis for the cause of such a transformation, and believes it to be the excessive warm temperature of the breeding-room. The caterpillar ready for transformation is prevented by the heat from producing the exudation of the fluids which are necessary for the formation of the chrysalis, and is obliged to transform directly into the moth. To ascertain his hypothesis he should have made experiments to produce such a transformation in an artificial way, by exposing caterpillars shortly before the fourth

moult to a high temperature. It will be of interest to know if the moths possessed well-developed genital parts, fitted for copulation and for the deposition of fertile eggs.

I have given purposely, in full, the original, as the two records existing disagree on some important facts. Lacordaire seems to have seen the original, as his record contains some statements not given by Meckel. Nevertheless, he has surely seen, and partly translated, Meckel's record, as is proved by the words: "les deux yeux noirs rapprochés," a verbal translation of the "Zusammengesetzten Augen," by Meckel. The presence of fore-wings only is recorded by Meckel, of hind-wings only by Lacordaire.

The statements given by Majoli are probable, except that the thorax, which is said to be similar to the third segment of the caterpillar, has four wings. The identity of the abdomen with the abdomen of the caterpillar consists perhaps only in elongation, as the presence of other parts is not mentioned.

Lacordaire considers the fact as proving the development of certain parts of an insect by precocity, though the other parts follow the common rule of development.

The fact would be a rather interesting one if it was beyond doubt. As silk-worms are raised every year by millions, I should have supposed that the observation would have been oftener made and published. Nevertheless, it is astonishing that such a fact, filling in some way the gap between insects with an incomplete metamorphosis, and those with a complete one, is not used by evolutionists.

A paper by the well-known Lepidopterologist, Mr. E. J. C. Esper, in Hoppe. Entom. Taschenbuch (for 1796), pp. 183 – 188, which I have not at hand, may possibly treat the question of a precocious development.

Majoli's observation is briefly reproduced (after Meckel) by Professor Van der Hoeven, in his quoted paper, p. 272. He remarks that no related observations are known, and that his observation rests only upon its own merits.

DEFORMITY OF THE ELYTRA.

Strategus (*Geotrupes*) *Julianus*.

The late Professor J. Wyman observed a specimen of this large beetle flying around in Florida in 1874. The movements were in some way strange and unusual, and induced Professor J. Wyman to catch the beetle. To his astonishment he found it perfectly developed, but the elytra wanting. The specimen, preserved in alcohol, he presented shortly before his death to the collection.

The specimen is a female, of thirty-six mm. length, and perfectly developed. The wings are in good and perfect condition, but there is no trace of the elytra; which are entirely wanting on both sides. Professor J. Wyman thought at first that the elytra had been removed by somebody, and the insect put again at liberty. But a careful examination of the living insect as well as of the alcoholic specimen by Dr. J. L. Leconte, and by myself, showed no lesion whatsoever in the place where the elytra should have been inserted. The anterior border of the mesothorax is horny and smooth, and near the scutellum exists a small membranous place without any wound. The legs, the prothorax, the upper part of the mesothorax, the metathorax, the scutellum, and the whole abdomen, are perfectly developed.

This case of deformity belongs to the "monstres ectroméliens" of Lacordaire, but as far as I am able to ascertain, no similar case is recorded. The fact that the beetle was able to fly without elytra is of additional interest.

Prionus coriarius.

This remarkable case is twice recorded, but later entirely overlooked. As I believe this kind of deformity of prominent value, I give a translation of the original communication by Dr. Saage in Preussische Provinzial Blaetter (1839), Vol. XXII, p. 191.

"One of my school-boys brought me to-day a male *Prionus coriarius*, the thorax of which presents a curious deformity. The horny dorsal cover of the mesothorax is wanting, and instead of elytra there are inserted, just in their place of articulation, two perfect legs, directed above and behind. The metathorax has the wings as usual, and the abdomen is of the same horny character as commonly, when covered with elytra. In attempts at flight the insect moved, together with the wings, the abnormal dorsal legs. The scutellum is wanting, and the prothorax has only two spines; all other parts are perfectly developed."

"Braunsberg, Prussia, July 10, 1839."

This communication is reprinted in Stett. Ent. Zeit., Vol. I, p. 48. The specimen was seen and examined afterwards by Professor von Siebold.

I have always considered this case to be a striking proof of the homology of the wings with the legs. No similar case has been recorded.

EXPLANATION OF THE PLATE.

FIGS. 1 - 5. — *Morpho Eurylochus*.

Fig. 1, side view. Fig. 2, the head of the same, magnified, showing beneath the separated mentum. Fig. 3, front view of the head. Fig. 4, the same from below, showing the forelegs. Fig. 5, head of the perfect imago.

FIGS. 6 - 9. — *Phalæna heteroclita*.

The figures are copied from the original in the *Mémoir. Prés. Acad. Paris*, Vol. VI. The plate given by Goeze is not exactly reproduced.

Fig. 6, the moth from above. Fig. 7, the same from below. Fig. 8, front view of the head. Fig. 9, the eggs.

FIGS 10, 11. — *Nymphalis Populi*.

The figures are copied from the *Bull. Acad. Bruxelles*, Vol. IV.

Fig. 10, the butterfly from above. Fig. 11, front view of the head.

The plate was intended to contain all figures given for this kind of deformity. When it was made, Mr. Bruinsma's paper was not known to me.

